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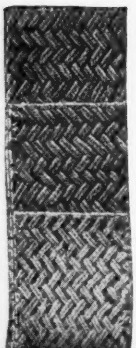

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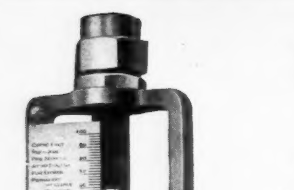

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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. XXI MARCH, 1916 No. 3

HIGH SPEED AIR COMPRESSORS FOR MINING SERVICE

BY J. M. WALSHE.*

Air compressing machinery appears to be developing along the same lines as the production of electricity, the slow-speed compressor giving place to the high-speed type, with its greater economy of material and space; and, where very large units are required, the turbo-compressor is supplying the need.

In the very large air supply stations on the Rand, turbo-compressor units of a capacity of 20,000, and even 50,000 cu.ft., requiring 4,000 to 13,000 horsepower, are quite a commercial proposition, and have proved a practical success.

Air compressors of this size are, however, very exceptional, and the high-speed reciprocating compressor is quite capable of dealing with the highest outputs so far required in this country; and, in the hands of manufacturers experienced in the design of high-speed steam engines, a very high standard of reliability and efficiency in operation is obtained.

Units of 1,000 to 1,300 hores-power are being successfully worked, and, owing to the relatively high speed of revolution, the weight of the parts and the space taken up are comparatively small. The speed, too, in the case of electrically-operated compressors, assists in keeping down the dimensions of the motor, and permits of the motor being directly connected.

The so-called "high-speed," or, more correctly, "quick revolution" type of compressor is now extensively used in mines and collieries, and any information concerning it should be of general interest.

For the air pressures required for power purposes in mining work, two-stage compression, with an inter-cooler between stages, is the design usually adopted in best practice.

The writer proposes to select as an example of this type of compresor the one with which he is most familiar, and which is probably more largely used than any other, at any rate, in England and the colonies, namely, the double-acting two-cylinder two-crank type, with automatic light plate air valves, and with the working parts lubricated on the forced lubrication principle.

In this type the air valves are placed on the side of the air cylinder, in which position they are readily accessible, and leave the ends free for the water jackets; and, seeing that the compression is mainly done at the ends of the stroke, this is a very desirable arrangement.

In this design it is impossible for oil from the crank chamber to be carried up into the air cylinder, as there is a distance in excess of the full stroke of the compressor between the cylinder and casing stuffing boxes. Another good feature is that piston rods are used, and not trunks. Although the differential trunk is a very usual design, and may be necessary in the case of small single crank compressors, it is one which should be avoided whenever possible. It will be appreciated that a trunk is much more difficult to keep airtight than a piston rod, and that a trunk working in and out of a crank chamber is liable to carry up a great deal of oil, whilst

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at the same time permitting air to pass down. Apart from the waste of oil, the oil thus carried up may become partly carbonized on the air valves, or distributed throughout the air system, to be detriment of the hose. An even more serious objection is that, if the air becomes heavily charged with oil vapour, dangerous explosions may occur in the air discharge piping or air receiver.

In the two-crank design, the circumference for leakage of piston ring and packing is only a quarter of that in the differential trunk design, and, moreover, the difference in pressure on the two sides of the pistons tends to reduce the leakage. For the rest, the forced lubrication system is too well known to need description, but a word may be said concerning the air valves, a most important part of any compressor.

AUTOMATIC AIR VALVES.

In one very efficient valve of this type, the valve seat and valve guard are made of cast iron. In the valve guard are recesses for four closing springs. Next to the seat comes the valve plate, made of thin tempered steel perforated to give a multiple opening. Parts in the slotted plate are ground down and especially tempered to form springs, which enable the valve plate to rise and fall through the small amount of its lift uniformly and without friction. Next above the valve plate is the lift washer, and then the cushion plate, made of thin steel, its function being to soften the blow of the valve plate when lifting.

As the working part of the valve is made of a tempered steel plate only $^1/_{16}$ in. or less thick, it has the advantage of extreme lightness, especially when considered in proportion to its surface area. As the lift is only about equal to the thickness, and the valve plate is guided in a perfectly frictionless manner, it is obvious that it will not be liable to hammer itself or its seat to pieces, and can be depended upon to continue to work for an indefinite period without failure, and without noise.

As previously stated, this type of compressor is especially adapted for direct connection to electric motors. The use of spur or helical gearing between the motor and the compressor should be avoided whenever possible, as (even if the cost of the motor is thereby reduced) the resulting loss of efficiency and possibility of noise and trouble with the gear discount largely any saving in price effected. In the case of motor driven slow-speed compressors, the use of ropes, belts, or other speed reduction gearing is a common practice, and the consequent loss in over-all efficiency is one of the draw-backs inherent to that type of machine.

The intercooler is provided with a central diaphragm plate supporting the tubes at a point mid-way of their length. The air that enters divides on this plate passing four times both upwards and downwards.

The cooling water is also arranged to pass four times upwards and downwards in a direction opposite to the air. The result is a very efficient intercooler, the air usually passing away to the second stage at a lower temperature than that at which the cooling water leaves the intercooler. The tubes and tube plate are of brass, similar in design to the best surface condensers, and can be removed for cleaning. The allowance of cooling surface depends to some extent, of course, on the temperature of the cooling water, but is usually at the rate of 1 sq. ft. for every 4 or 5 cu. ft of free air compressed per minute.

The same design with a strengthened casing makes a very efficient after-cooler. There is a growing tendency, doubtless based on experience gained, to use after-coolers, presumably to improve the quality of the air. A great deal of the moisture in the air is condensed in the after-cooler, and any oil or dirt which may have come through the compressor is also deposited there.

A great point in favour of the adoption of the turbo type of compressor for colliery or mining work is that exhaust steam can be used in the turbine operating the compressor; but it may be pointed out that the exhaust steam can be utilised more economically by coupling the exhaust steam turbine through gearing to a high-speed reciprocating compressor. Such a plant has been in successful operation for three years past at the Glass Houghton Colliery of the Glass Houghton and Castleford Collieries Limited, and has proved a practical and commercial success. Before this novel combination was adopted, the direct driven turbo-compressor received full consideration, but, from estimates received from a large number of makers, both Brit-

ish and Continental, it was apparent that a turbo-compressor capable of dealing with 6,600 cu.ft. of free air, and delivering that quantity at a gauge pressure of 70 lb. per square inch, would require at least 21 per cent. more power to operate it than a reciprocating set.

The efficiency of turbo-compressors may have been improved of late years; mechanically, they are greatly improved, but they are still far from being as efficient as reciprocating compressors of equal output. Moreover, in mining work, where necessarily compressors often run during some portion of the 24 hours at loads much below the full load, the reciprocator possesses still greater advantages, as, for reasons which will be stated later on, the efficiency of turbo-compressors is very low at the lighter loads.

In the plant now in use, the air compressor is of the vertical two-crank double-acting type, suitable for the specified duty when running at a speed of 163 revolutions per minute, and fitted with automatic plate valves of the kind previously described. The turbine is of the mixed pressure type, and the gearing of the double helical type supplied by the Power Plant Company, the bearings being forced lubricated from the system which supplies the turbine. Flexible couplings are fitted on both sides of the gearing. The gearing first supplied was not entirely satisfactory; but, as a result of certain modifications that were made, the initial difficulties were overcome, and the success of the gear drive is now beyond question.

In consequence of the satisfactory performance of this plant, another similar plant of slightly smaller dimensions is now in course of construction, and when the advantages of this combination become more widely known, it is likely to be generally adopted, although for units of considerably larger output the turbo-compressor will hold the field.

EFFICIENCIES.

As is the case with steam turbines, the efficiency of turbo-compressors improves with the size, and for the very large sizes in use on the Rand, the efficiency, if not equal to that of a reciprocating compressor, is still not much below it, and their low first cost is greatly in their favour.

When the performances of compressors are contrasted, the only satisfactory basis of comparison is the over-all efficiency. When a comparison is made between steam-driven compressors running under similar conditions of steam supply and air output, the number of cubic feet of free air compressed per pound of steam consumed is a very convenient figure for the over-all efficiency. The equivalent figure for an electrically-driven compressor is the number of cubic feet of free air compressed per kilowatt input to the motor. These expressions are, however, unsuitable when compressors operating under dissimilar conditions are compared, and it is better to state the over-all efficiency as the ratio of the power available in the air delivered to that supplied to the engine or motor driving the compressor.

There is a natural tendency, on the part of manufacturers whose machines may show a specially good intermediate efficiency, to make the most of that particular feature; but each stage in the process of compression should be equally good, if a high over-all efficiency is to be obtained.

VOLUMETRIC EFFICIENCY.

A high volumetric efficiency, for instance, does not necessarily imply a high efficiency compressor. *As a matter of fact, a low volumetric efficiency may indicate liberal ports and valves, and consequently very small pressure losses in the compressor, resulting in a high over-all efficiency.*

When compressors were bought and sold on the "swept" volume of the air cylinders, and not on the actual quantity of air compressed, the volumetric efficiency was a matter of great importance to the purchaser. Nowadays compressor contracts are unusually based on compressor output, and, provided that the compressor yields its full specified output of air, the volumetric efficiency is of little interest to the user. So long as the purchaser obtains the specified output of air compressed to the required pressure by the consumption of not more than the specified amount of steam or of electrical energy, he need not trouble himself about the volumetric efficiency, or any other of the various "efficiencies" which are so often quoted.

The over-all efficiency of an electrically driven compressor is the ratio of the isothermal horse power in the air discharged to the electrical horse power input to the motor. A good modern direct-coupled, high-speed, motor

driven compressor will show an over-all efficiency of from 60 to 65 per cent. The higher over-all efficiency in the case of the electrically driven compressor is explained by the fact that the conversion of electrical energy into work is, in our present state of knowledge, a much more efficient process than the conversion of the heat energy of steam into work.

AIR REGULATION.

The economical working of a compressor is affected to a large extent by the means adopted for controlling the air output. The most economical method is to vary the speed of the compressor in proportion to the demand for air. To effect this an air governor, working in conjunction with a centrifugal speed governor, controls the speed of a steam driven air compressor. For air pressures up to the full working pressure, the compressor is under the control of the centrifugal governor. When the working air pressure is exceeded, the air governor takes control, varying the speed in proportion to the demand for air. It operates in the following manner:—

When the air pressure is below the working pressure, a relay valve is held in its inner position by springs at the end of a lever. In this position the air pressure is shut off from the cylinder, which is open to the atmosphere through the exhaust port, and the speed of the compressor is under the control of the centrifugal governor. Excess air pressure lifts the relay valve against the resistance of the springs, shutting the exhaust port and admitting pressure behind the plunger. The latter moves outwards, depressing the near end of a rocking lever, and raising at the other end the vertical rod attached to the steam throttle valve, thus reducing the supply of steam to the engine. Since the lower ends of the springs are connected to the rocking lever, the movement of that lever increases immediately the tension on them, the relay valve is forced back to a middle position over the cylinder port, and the gear remains stable in the new position. On any further rise in air pressure the operation is repeated, and the steam supply is still further reduced.

A falling air pressure has the reverse effect. The lower air pressure under the relay valve is insufficient to maintain it in the middle position, and under the pressure of the springs it moves inwards, allowing some of the air behind the plunger to escape into the atmosphere. The plunger is thereupon moved inwards by a main control spring relieving the tension on the relay valve springs, and allowing the relay valve to center itself again. With a variation in the air pressure of less than 5 per cent., the range of speed obtainable is about 5 to 1. Without the relay principle embodied in this design the speed control would be intermittent, that is, the compressor would run either at full speed or at the minimum speed. Although a common arrangement, it is not so efficient as the one just described.

Variable speed can also be secured in connection with compressors driven by direct current motors, and to a limited extent in the case of alternating current motors; but, owing to the increased cost of the motor, variable speed is not usual for electrically driven compressors of large size. Automatic stopping and starting devices are occasionally used for the smaller sizes, but, in general, electrically driven compressors are so devised as to run at constant speed.

A common form of unloading device for constant speed compressors is the automatically operated air inlet throttle valve. When the action is intermittent, this is the simplest and most efficient arrangement. When the inlet valve is designed to throttle the air gradually, there is a considerable waste of power at light loads, and the temperature of the air discharged is liable to become excessive.

With an intermittent automatic air inlet valve, under normal conditions the inlet valve is full open, and there is no waste of power due to wire-drawing the air. Excess air pressure shuts the valve completely, and the no load losses are practically confined to the unloaded friction of the compressor. Since no air is being drawn in, there is no churning of the air through the delivery or suction valves.

Where automatic stopping and starting gears are used, the air pressure at the discharge side of the compressor should be released before the motor is started again. This necessitates a non-return valve in the air main close to the compressor, and a relief valve automatically operated by the motor starting gear.

Owing to the inertia of the flywheel and moving parts at full speed, the full load torque is proportional to the mean pressures in the air cylinders; but, when starting, the flywheel effect is absent, and the resistance to

rotation is that due to the maximum discharge pressures on the air pistons.

A compressor of a capacity of 450 cu.ft., driven by a 440-volt direct-current motor, recently tested by the author, required about twice the full load current at starting when the motor had to start up with the full air pressure on the compressor outlet valves. When the air pressure at the discharge was released, the starting current fell to less than 50 per cent. of the full load value. Other tests carried out on the same compressor have demonstrated that relief of the pressure at the discharge is much more effective in reducing the starting torque than shutting off the air at the inlet.

TESTING FOR LEAKS.

The maintenance of a high standard of economy involves occasional tests for piston and air valve leakage. When indicators are available internal air leakages can be detected readily by the shape of the diagram, or by comparing the apparent volume of free air drawn in with that shown at the discharge. The temperature and pressure of the air entering and leaving the cylinder must be known in order to calculate the amount of air that is passing.

A standing test will often reveal leakages too small to affect the running intercooler pressure. To carry out a standing test, stop the compressor, leaving it connected to the full air pressure in the receiver, and observe the discharge and intercooler pressure gages. When the air valves are in a good state of adjustment, the pressure in the receiver and the intercooler will remain stationary, or fall only very slowly. Leakage past the second-stage valve will cause the intercooler pressure to rise; on the other hand, leaky first-stage valves will allow the air to escape from the intercooler, and the pressure to fall.

If there are indicator cocks fitted to the cylinders, the leakage can often be traced to the offending valve or valves by opening the cocks in succession, starting at the first stage. When the air valves are in good order, the flow of air from the open cock will be quite feeble, not sufficient to extinguish a candle held in the stream 6 in. from the cock.

AIR SURGING.

Special consideration should be given to the arrangement and preparations of the pipework close to the compressor. Owing to the pulsating motion of the air flow, surges can be set up which affect the efficiency of the compressor. If, for instance, the pipe on the inlet side is of the critical length in proportion to its diameter, air surges will be set up which, if their period synchronises with the beat of the compressor, may become so much intensified as to increase greatly the flow of air into the compressor. The increased volume of the air passing is, of course, accompanied by an increase in the power required, and, when the compressor is electrically driven, this may cause an overload on the motor. In one instance, where the motor operating the compressor was considerably overloaded, it was found that elimination of the inlet pipe resulted in a drop of no less than 40 horse power in the power required to operate the compressor. When the inlet pipe has happened to be of suitable proportions, the air flow has been so stimulated that volumetric efficiencies in excess of 100 per cent. have been demonstrated.

The effect of these surges in the inlet pipe has been found to increase the output by 15.6 per cent., and the power required by 17 per cent. This effect is not, of course, peculiar to high speed compressors; cards showing the same characteristics have been obtained from slow speed compressors. The surge can be eliminated by a considerable increase of the bore of the suction pipe close to the compressor. From 10 to 15 ft. of piping, of an area large enough to reduce the air speed to about 10 ft. per second, is effective in most cases.

The increased output obtained when the air surge occurs on the suction side is some set off for the additional power required; but when the surge is on the discharge side there is no similar compensation, and the extra work due to the surge is wholly wasted. Surges on the discharge side can be greatly minimised by increasing the pipe capacity to the compressor.

These surging effects are naturally of greater importance the lower the delivery pressure is at which the compressor works; and in the case of a compressor operating at a pressure of 5½ lb. per sq. in., such surging effects occurring in the inlet and discharge pipes have been known to increase the power required to operate the compressor by as much as 30 per cent.

It might be supposed that surging effects would be absent in the case of rotary or turbo-compressors, but such compressors are specially liable to be adversely affected in this way. With turbo-compressors, as the output is reduced, a point is reached (generally about five-eighths load) at which the air begins to surge to and fro in the compressor, causing shocks, noisy working, and very high air temperatures. This tendency to surging is responsible sometimes for serious difficulties in running turbo-compressors in parallel delivery into a common main. The remedy usually applied is to keep the output above the critical load by discharging part of the air direct to the atmosphere. To blow the surplus air to waste is undoubtedly the most efficient method of controlling the output, and one that would not be entertained in the case of a reciprocating compressor.

STRAINING ARRANGEMENTS FOR AIR.

It is important—at any rate, if there is much dust about—that some adequate arrangements should be made for filtering the air, and the expense involved in so doing will prove to be amply repaid by the improved results derived from the air compressing plant and tools. At a colliery there is almost invariably a great deal of dust, and in an extreme case it has been found that, not only have the airways into the compressor become choked with a caked composition of coal dust and oil, but that the clearance spaces in the air cylinders have been entirely filled up, causing the compressor to knock. The dirt also accumulates on the valves, thus increasing their weight, and therefore the risk of breakage.

The inter-cooling efficiency is also impaired, with a resulting increase in the air temperatures. Undoubtedly a considerable proportion of the dirt is intercepted in the receiver, but some is certainly carried on into the tools, increasing their wear and tear and liability to derangement. On the whole, there is no doubt whatever that an air filter is a paying proposition. In some cases where it has not been considered advisable to incur the expense of such a filter, the inlet pipe has been removed, and the compressor arranged to draw its air supply from the compressor house, thereby avoiding to some extent the dust; but this course is not advisable, as the noise arising from the air inlet is very unpleasant, to say nothing of the fact that the air is, as a rule, being drawn from the compressor room at a temperature higher than that outside.

The arrangements for filtering the air must be adequate for the purpose. It is useless to set up, as occasionally supplied, a frame of wire gauze very little larger than the air inlet pipe on the compressor. Such a sheet of gauze, if of fine enough mesh to filter the air effectively, very quickly becomes choked with dirt, and may go to pieces and pass into the compressor.

One simple and comparatively inexpensive straining arrangement was developed on the Rand, where there is a vast quantity of dust, and this form has become almost standard in that area. The straining material is of the best cocoanut matting supported by wire netting, and is enclosed in wooden frames, which are so arranged as to form a box, into which the intake pipe of the compressor is introduced.

The frames are secured by bolts and flynuts, and are thus easily removable when it becomes necessary to clean them, a spare frame being substituted. Experience has shown that the area of matting should be about 50 to 60 times the sectional area of the inlet pipe. Two strainer houses, each having 32 of these strainer frames, are in use in connection with four high speed compressors, each of a capacity of 6,500 cu.ft., at the New Modderfonteen gold mine on the Rand. The houses stand apart from the main building, and the air is carried into the compressor house by culberts under the floor, into which the inlet pipes of the compressors dip down.

Each of these four compressors is operated by a synchronous motor of 1,000 horse power running at 163 r. p. m. A special characteristic of these compressors is that, influenced doubtless by previous experience, the mining engineer specified the intercoolers should be so designed that the whole of the tubes could be readily lifted out and dropped into a soda tank, in which they might be boiled for the removal of the grease. Reports received after more than two years' operation showed, however, that very little dirt or grease had accumulated.

Although each compressor was fitted with 40 light-plate air valves, 160 in all, none of them had become broken after two years' running. The mining engineer considered that this, as also the cleanliness of the compressors

and intercoolers, was attributable largely to the excellence of the arrangements made for cleaning the air, and, further, to the very small quantity of oil used for internal lubrication of the air cylinders. Less than a pint of oil is used in each of these large compressors for a continuous run of 24 hours. About three-quarters of this is used in the air cylinders and the rest in the crank chamber.

In another installation of two electrically driven air compressors, each of a capacity of 1,500 cu.ft., working at a pressure of 100 lb., the air filtering arrangement consists of frames such as described above, with a roof to keep off the rain, the air inlet pipe being carried underground. If necessary, in the interests of the motor, the pressure can be relieved from the discharge pipe before starting up by closing the 6 in. sluice valve and by opening the safety valve, gear being provided for the purpose.

THE BONTEMPI RUST-PROOFING PROCESS

This process, invented by Augusto Bontempi, an Italian chemist, consists in the oxidizing of the surfaces of cast and wrought-iron and steel pieces used in engineering work, thus rendering them able to withstand for a practically unlimited period the corrosive action of the atmosphere, of water, and of sulphurous and other gases.

The pieces to be treated are first cleaned by means of emery-paper or by sand-blasting. They are then placed in a kind of steel-wire cage; this is driven inside an air-tight muffle which has been previously heated by means of gas-jets. When the muffle has been closed in front, after insertion of the pieces to be treated, superheated steam is delivered inside the muffle, with the object of preparing the surfaces of the pieces for the subsequent action of chemical fumes. After the pieces in the muffle have been subjected to the action of the superheated steam for about 30 minutes, the delivery of steam is cut off, and the chemical substance, in the form of a powder, is placed in a separate retort at the back of the muffle. The retort is heated separately, also by gas-jets; the fumes from the chemical powder enter the muffle under pressure, and give the pieces under treatment a protective coating of oxide. On the cage being removed from the muffle, it is covered by a casing, to allow of gradual cooling.

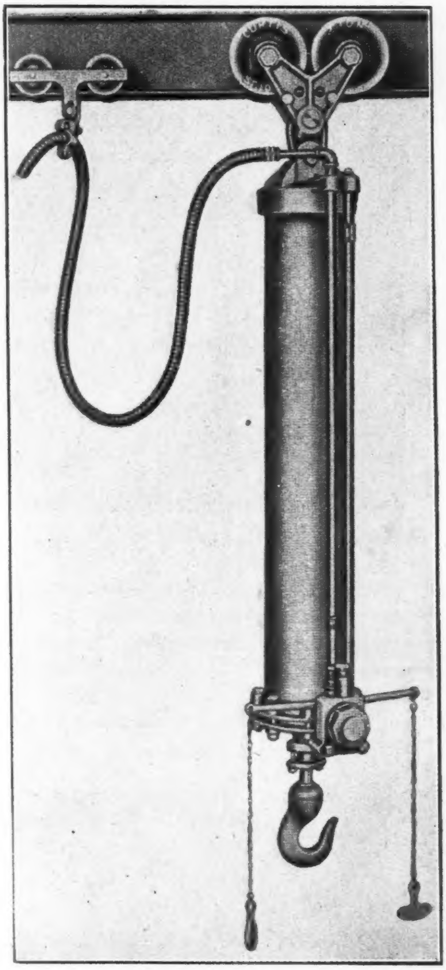


FIG. I. TYPICAL VERTICAL AIR HOIST.

PNEUMATIC HOISTS

There is little or no novelty in the present article. It is a simple account of some of the familiar types of air actuated hoists in use, with some consideration of their advantages or the reverse, and is substantially a reproduction of a portion of an article, "Hoists for Manufacturing Plants," in the February issue of the Engineering Magazine.

The simplest and cheapest type of power hoist is the direct-acting compressed-air lift, Fig. 1. It consists essentially of a vertical cylinder in which a single-acting piston carries a rod projecting through the lower cylinder head by means of a stuffing box. A crane load-hook is attached to the lower end

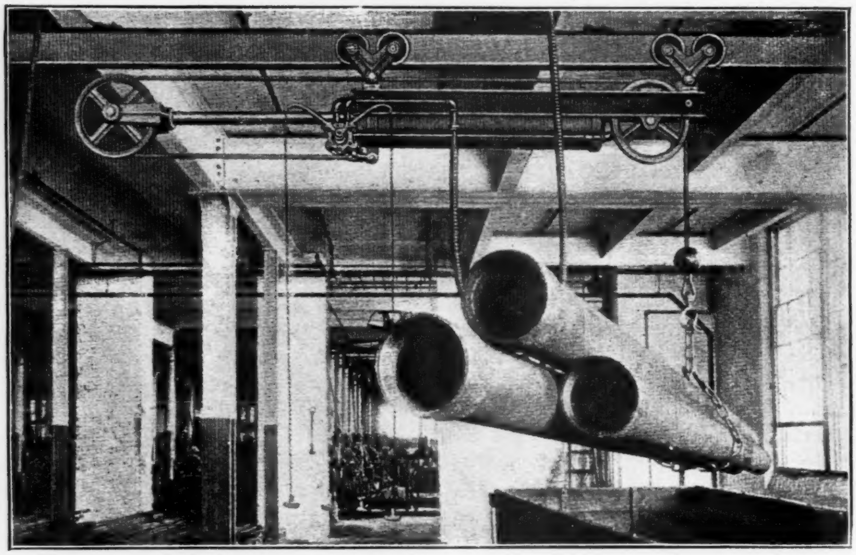


FIG 2. AIR HOIST WITH HORIZONTAL CYLINDER.

of the rod. The valve, which controls the admission of air to the underside of the piston, is operated by a double-ended lever with pendant cords. The inside diameters of the air cylinders vary from 3 to 24 inches in standard hoists, while the stroke varies from 4 to 8 feet. It is obvious that the capacity of a given hoist depends on the air pressure used. With the usual air pressure at 60 to 100 pounds per square inch, the 3-inch hoist will lift from 350 to 600 pounds, while the 24-inch hoist will lift from 24,000 to 40,000 pounds.

This hoist will hold the load in position as

FIG. 3. HOIST WITH MOTOR.

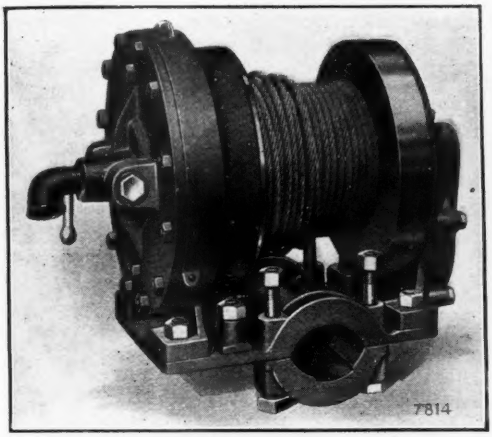


FIG. 4. LEYNER GEARED MOTOR HOIST.

long as there is air at the proper pressure beneath the piston. In order to prevent the load from being dropped because of a broken air hose, a safety check valve is usually fitted on the hoist cylinder.

One of the disadvantages of the direct vertical air hoist is the head room required, and to overcome this difficulty, the cylinder is sometimes placed in a horizontal position and a rope or chain is utilized to get a vertical hook motion, Fig. 2. This type has several other advantages over the direct vertical type. The first is, that the lift may be doubled without increasing the stroke of the piston; another is that the high-pressure air, used for hoisting, acts in the head end of the cylinder and, hence, not on the stuffing box. The hoist must be made double acting, however, in order to force the piston back to the head end of the cylinder when there is no load on the hoist. The pressure required for this operation is small, so there is little stuffing-box trouble.

Another disadvantage of the air hoist is that its range of action is limited by the length of the air hose. This does not prevent a certain amount of mobility, however, and does not make it impossible to use the hoist on a short-travel trolley.

To overcome some of the disadvantages of the direct-acting hoist, the hoist illustrated in Fig. 3, has been designed by the Ingersoll-Rand Company. The power unit is a three-cylinder reciprocating engine, or motor, such as is used on pneumatic drills and reamers. The crank is stationary, and the cylinders revolve. Air admission and exhaust is controlled by ports in the stationary crank, thereby eliminating valves. The motor is geared to the hoist drum by means of a worm and worm-wheel in the small sizes; a pair of spur gears is added in the larger sizes. As in the hand-operated screw hoists, there is no brake needed to hold the load in any position. The operating valve is of the reversing type, so the motor may be run in either direction, and is so arranged that it will close automatically when the pendant operating cords are released. There is also an automatic stop which closes the valve when the load has been raised to the top. This hoist is built in the five sizes shown by the table below.

A type of motor similar in results to the above is shown in Fig. 4, and in action in Fig.

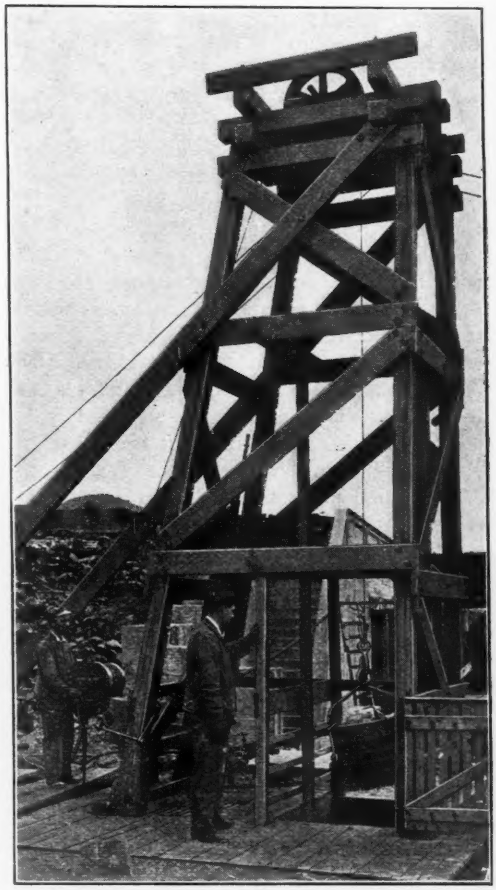


FIG. 5. LEYNER HOIST IN SHAFT SINKING.

5. It has a considerable range of lift and is used for light shaft or well sinking and for general "knock-about" service. As will be seen, it is entirely enclosed and self-contained, is lubricated by a splash system, and is built with the idea that it will be used by inexperienced operators and under the severest conditions. The capacity is 1,000 pounds, with a rope speed of 85 feet per minute with air at 80 pounds pressure. The drum has a capacity of 700 feet of 1/4-inch or 450 feet of 5/16-inch rope.

SUCCESS OF LIQUID AIR IN BLASTING

We have to confess that we have had little expectation that liquid air could ever be successfully used for mine blasting, for the simple reason, if for no other, that it evaporates so rapidly. The following written by a correspondent of The Engineering and Mining Journal, seems to give a very authoritative and convincing story of actual success with it, with a probability of permanent employment.

The use of liquid air as an explosive has been known ever since the famous Professor Linde took out the first patent in 1895. It was used in the building of the Simplon Tunnel, and has been tried in a number of countries, notably France. But until very recently it was regarded as still in the experimental stage. Immediately upon the outbreak of the war it was put into practical operation throughout the German mining industry. The results have proved so successful that it is now certain that it will continue to be used in place of dynamite even after the war.

In the first place it is peculiarly safe. You can take a cartridge—as they call the little black mouselike bags—put it into the bucket of liquid air which, literally, steams with cold, until the cartridge has soaked up 90 gr. of it, and then, with the assurance that you are dealing with an explosive more than half again as powerful as the ordinary charge of dynamite, you can put it down and step on it, and the only result is a fizz as of so much steam. I saw five of these cartridges jammed with a stick into the holes drilled in the rock just as if they had been so many wet rags. And then I saw the men running like mad, when the electric current was turned on and the pieces of rock began to fly.

The cheapness is another advantage. Over against 20 pfennigs, the approximate cost of a dynamite cartridge, one cartridge saturated with liquid air costs, at this Rammelsberg mine, only 12 pfennigs. And where it is made in larger quantities, the cost is even less. A whole new industry is in the process of development in Germany to manufacture and handle liquid air; and the principal firm, the Marsit Corporation, declares the cost of liquid air to be just one-half that of dynamite.

DRILL STEEL AND ITS TREATMENT

The following by E. M. Weston, Johannesburg, South Africa, here reproduced in abstract from The Engineering and Mining Journal, Dec. 18, has to do with tests conducted by the Mines Trial Committee during 1910-11. While they should be of interest to mining engineers in all parts of the world they have never before been published. It is much to be regrettted that the work was all done by hand, and that nothing was apparently known of the excellent work now done by the Leyner drill sharpener, which suggests that a supplementary paper should follow this.

The alloy steels referred to are steels containing chromium, banadium or tungsten, and perhaps aluminum, while the carbon steels are the ordinary steels with manganese and a little aluminum.

When heated steel is hardened by plunging it into cold water it is often too hard and brittle. This defect is diminished and the steel is made tougher at the expense of hardness by heating it to some temperature 200°—300° C. for a short time. This operation is generally necessary in the case of high carbon steels, but with ordinary steels of lower carbon content it can be dispensed with by quenching in hot water.

CRITICAL TEMPERATURES.

On heating a piece of rock drill steel slowly and observing its rate of rise of temperature with a pyrometer, a halt will be observed to occur between 700° and 750° C., denoted by the sign *Ac*. On slowly cooling a similar halt is observed, usually 30° C. below *Ac*, and this is denoted by *Ar*. The halt at *Ac* is due to the expenditure of heat in producing microscopical structural changes, the steel being converted into mortensite. This structure is retained if the steel is suddenly cooled, and the steel is hardened.

If the steel is cooled slowly it becomes soft, or is annealed, owing to the change of the mortensite into pearlite and ferrite when the steel contains less than 0.9% carbon, or into pearlite and cementite when carbon exceeds 0.9%. Ferrite is very soft, pure iron. Cementite is hard, brittle carbide of iron. Pearlite is a mixture of the two. The points *Ac and Ae* are called the recalescent or critical points of steel.

THE TESTS.

The steels tested were 1½ in. cruciform, 1 in. and ⅞ in. octagon, and were used in 2¾ in. stoping drills. They were given the necessary heat treatment, and the bits were measured, inspected and weighed before and after being used. The distance drilled was noted and sometimes the drilling speed. Various marks were allotted for merit, and the question of price also was considered. Chemical analyses were made of the various steels, and a fair idea of the class of steel most suitable for work in the hard quartzites of the Rand, and inferentially in hard ground elsewhere, was attained.

First, with regard to loss of reaming efficiency with ⅞ in. octagon drill steel, a comparison of the steels giving the best and the worst results showed.

For the Best		For the Worst	
Carbon	0.800%	Carbon	0.640
Silicon	0.070%	Silicon	0.180
Sulphur	0.012%	Sulphur	0.020
Phosphorus	0.029%	Phosphorus	0.032
Manganese	0.270%	Manganese	0.430

This showed lower carbon content and greater sulphur and manganese in the poorer steels.

With regard to loss of weight through wear, the results showed:

For the Best		For the Worst	
Carbon	0.770%	Carbon	0.650
Silicon	0.110%	Silicon	0.100
Sulphur	0.010%	Sulphur	0.020
Phosphorus	0.029%	Phosphorus	0.026
Manganese	0.290%	Manganese	0.380

This shows a similar result, and the bad effect of phosphorus.

The general results of the tests were:

A. Although some of the alloy steels have shown excellent drilling results and are not costly in steel consumption, not one of them is equal to the rest of the ordinary carbon steels. With alloy steels a uniform composition is harder to obtain than with carbon steels. The former have more tendency to overheat and are more difficult to weld.

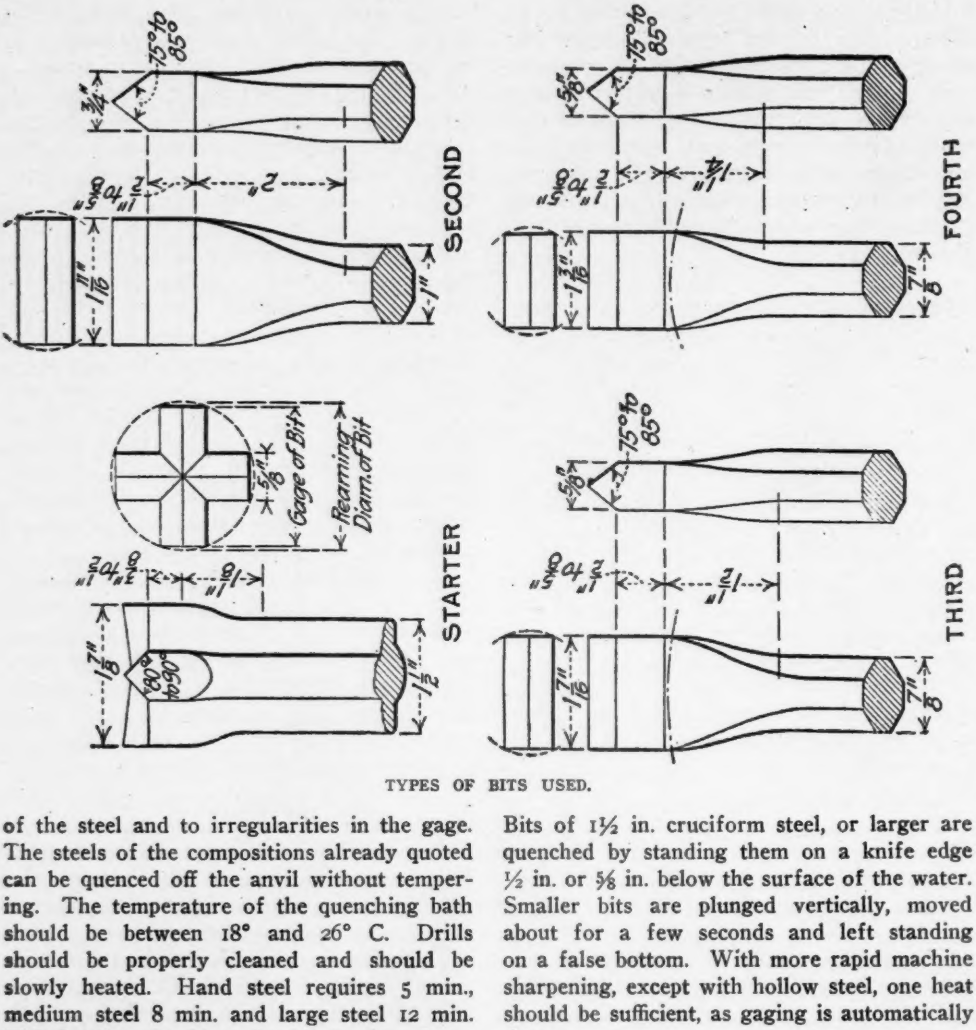
B. Best 1½ in. cruciform steel: Steel having carbon content above 0.75% was rejected, owing to the difficulty of welding it. It was also found that, as a general rule, the larger the size of steel the lower should be the carbon content, as the difficulty of equal or regular heating and quenching increases with the size of the steel. The best steels of this size had a composition: Carbon, 0.66% silicon, 0.09%; sulphur and phosphorus, 0.036%; manganese, 0.28%.

C. Of the 1-in. octagon steel the best had a composition of: Carbon, 0.69%; silicon, 0.09%; sulphur and phosphorus, 0.036%; manganese, 0.30%. Of the ⅞-in. octagon steel the best had a composition of: Carbon, 0.72%; silicon, 0.09%; sulphur and phosphorus, 0.035%; manganese, 0.27%.

Bits made from sections larger than 1½-in. cruciform are much larger, and in rapid working they tend to overheat if the interior is properly treated, thereby decarbonizing; quenching is also difficult. These steels should contain from 0.60% to 0.65% C. In all these steels the maker should be allowed to use aluminum as a purifier if not more than 0.10% is left in the finished steel. The best steels were Swedish bessemer, crucible, open-hearth (mostly) and electric crucible. Steels were found to improve after being sharpened several times, probably owing to the effect of hammering on the grain of the steel.

PARTICULARS OF THE HEAT-TREATMENT.

Usually, on the Rand, all drills except those of hollow steel are heated but once for a long distance from the bit. They are rapidly sharpened, they are not gaged and are quenched without reheating. This method tends to over-heating, to the decarbonization



TYPES OF BITS USED.

of the steel and to irregularities in the gage. The steels of the compositions already quoted can be quenced off the anvil without tempering. The temperature of the quenching bath should be between 18° and 26° C. Drills should be properly cleaned and should be slowly heated. Hand steel requires 5 min., medium steel 8 min. and large steel 12 min. This heating should preferably be done in an oil furnace, as overheating is very liable to occur with coal fires, especially when watched by natives. The drills should be heated to a bright orange red heat (about 1,050 C.) for 1¼ in. for hand steel, 2 in. for medium sizes, 3 in. for large steel, and be thoroughly and regularly heated through the mass of the steel. The heated drill should be forged until it cools to a dull-red color, about 600° C. With hand sharpening, this should take from 45 to 60 sec. The bit should be at once reheated to a bright-red color, about 950° C. It should then be finally sharpened and carefully gaged until a cherry red color, about 750° C. This should take another 45 sec. Bits of 1½ in. cruciform steel, or larger are quenched by standing them on a knife edge ½ in. or ⅝ in. below the surface of the water. Smaller bits are plunged vertically, moved about for a few seconds and left standing on a false bottom. With more rapid machine sharpening, except with hollow steel, one heat should be sufficient, as gaging is automatically done.

Quenching tanks should be supplied with cold water at the bottom at three places and should have a false bottom, as well as frame and knife-edge below water level. They should be fitted with an indicating thermo-telegraph thermometer, so that the necessary temperatures can be maintained. Usually the bath is allowed to be too cold in the morning and to get far too hot later in the day. If steel is quenched at above 800° C., the grain gets coarser, the tensile stress and the elongation both become less. The higher the carbon contents of the steel, the higher should be the temperature of the water for quenching. If, however, it requires a higher water

temperature than 35° C., the carbon content is too high for rock drills unless tempering is employed. Shanks of drills may be tempered by leaving them for a minute in a molten-lead tank 1 in. deep, covered with ashes; if somewhat harder shanks are required, a little tin may be added to the lead.

The loss of weight per inch drilled with the very best steel was 0.4 gram, and good steel averaged about 0.6 gram, costing about 0.015 penny. The total cost of solid steels and its sharpening is 6% of stoping costs of 4s. to 6s. per ton. With hollow steel it is about twice as much. The best steel could be bought in Johannesburg at from 4d. to 4½d. per lb. The loss of steel per inch drilled was found to be the same with all three sizes of steel experimented with.

DESIGN OF DRILL BITS ADOPTED.

The style of drill bits adopted has been already illustrated in the *Journal*, but it deserves further notice.

It was stated that chisel bits were found by experiment to be the fastest drillers and this was claimed to be due to the facts that they occupy only 50 to 63% of the hole and that they allow the escape of mud better. This reason is open to question. The four square reaming edges, of the depth shown in the sketch, were adopted. I have seen such a design of bit recommended for hammer drills, but it is opposed to all accepted theories of the correct formation of the wings of piston-drilled bits. One might suppose that it would prejudice the rotation of the drill in the hole, but the fact remains that the experimenter got most excellent results in hard ground from this design, and I commend it to the attention of mining engineers elsewhere. The next point of interest was that the experimenter showed that by using gaged steel, more carefully sharpened, and drilling larger holes, it was possible to reduce the drills used per fathom broken from 35.8 to 26.6. Gaging may take 25 to 30% more time and add to the cost of sharpening, but it pays for itself. The reaming diameter of the holes drilled was greater than the nominal gage. The experimenter says of these square reaming edges: They should be hardened for ¾ of their length. (1) They help by reaming out the hole to keep it from decreasing in diameter too rapidly. (2) They prevent "wobbling" of the drill in the hole and thus preserve its cutting edge and reduce wear and tear on machine. (3) The drill passes slips or heads better.

The thickness of the bit should be kept about ⅝ in., otherwise the reaming diameter is increased too much. There was a great difference in gage used; 3/16 in., ¼ in., and ¼ in., as shown by the following table:

The experimenter remarks that it would be possible to reduce the gage. This is evident. Owing to vibration of the drill in the hole, the hole bored is always 0.05 larger than the bit, so that all the difference necessary between different steels would have been about ⅙ in., or 0.17 in. This would have meant an increase of drilling speed equivalent to starting the hole at about 1⅝ in. instead of 1⅞, probably 10 to 15%. This is a matter that received far too little attention, owing to the mistake of using the same steel to drill dry holes as to drill wet holes.

Another series of experiments showed the benefit of gaging steel. The ordinary run of mine steel was found when new to differ from 0.09 in. to as much as 0.17 in. from the proper gage, while the gaged steel hand-sharpened was found to differ only between 0.01 and 0.03 in. from standard.

These experiments undoubtedly were most valuable and pointed out the way to a great increase in efficiency in stoping on the Rand. Yet, except in the case of perhaps one or two mines, the results have received no attention whatever. Machine drills are, when sharpened by hand, as badly sharpened as ever, though the quality of the supply of drill steel itself has been standardized very well.

CARE OF PNEUMATIC TOOLS*

BY AUGUST MEITZ.

In handling pneumatic tools several points are to be taken into consideration. First of all, it is a good policy to adopt a standard of such tools on any one railroad system. This plan would reduce the cost of repairs and maintenance about 50 per cent. as well as reduce the expense for repair parts to be carried in stock in order to expedite repairs and to prevent holding tools out.

In selecting pneumatic tools for service a great many mistakes are made as regards

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*Proceedings American Railway Tool Foremen's Association.

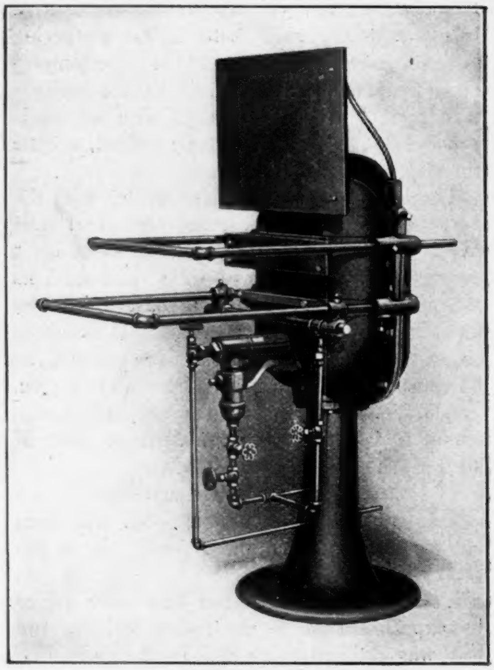
to speed and power. For instance, an air motor of high speed will be used by a boiler maker to drill out stay-bolts; and as soon as he has completed this drilling, he will use the same motor for running in a stay-bolt tap, say $1^1/_{16}$ in., thereby using the same speed as he had just used on a $^{13}/_{16}$-in. high-speed drill. In such cases damage is often done to the motor as well as to the tap—the motor is overloaded and the tap is overspeeded, with the result that the motor will break in some place and the tap is spoiled. The same result is had by drilling and reaming at too high speed on the motor—the reamer is spoiled. Taking the standard rule, "What is gained in speed is lost in power," we come to the conclusion that it is unwise to have all high-speed motors in any one shop, as the little time gained by drilling is a double loss in spoiled drills and taps which, if handled in a more reasonable manner, would pay for the lost time.

All motors should be kept clean and well oiled at all times. Good engine oil should be used, and it will also be found to pay to use some light grease to fill the case or crank chambers.

Air hammers should always be well oiled before using. A light mineral oil, we have found, gives best results. Any oil which will gum or thicken in cold weather should be avoided. After a hammer has been in service and returns to the toolroom, it should be placed in a solution of gasoline and signal oil, equal parts, as small particles of rubber from the hose lining frequently lodge in the chamber between the handle and the throttle-valve sleeve. The gasoline mixture will cut this rubber, and by blowing out the hammer with compressed air, all refuse and foreign substances are removed. After the hammer has lain in the oil about five minutes, it should be taken out and hung up to drip. Before the hammer is used again, all parts should be properly oiled.

Others find that if air hammers are kept in a coal-oil bath when not in use, there is very little repair work to be done on these tools until some part becomes worn so that it must be replaced by a new one.

The throttle handle of the motor is filled with coal or signal oil every evening, which prevents throttle valves from sticking and also keeps the valves of the machine clean.



LEYNER OIL FURNACE WITH PREHEATING FEATURE

The No. 3 Leyner oil burning furnace, here shown in the halftone, which is used extensively for heating drill steel, is now made with a preheating chamber which greatly increases the capacity of the furnace. The preheater portion fits between the body and cover of the furnace of the old design and it is a simple matter to attach this section to an old furnace by changing a few bolts. The lower chamber is used for the final heating and the upper one for preheating.

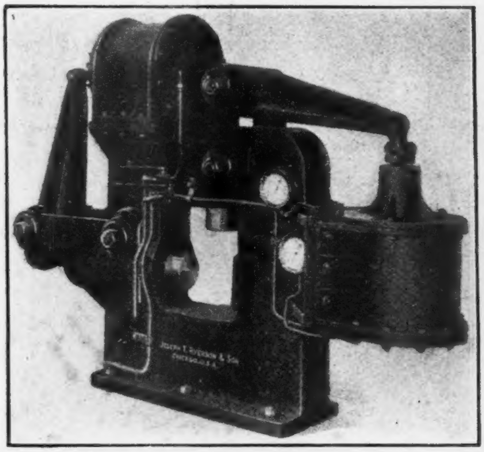
It is claimed that by the addition of the preheating feature, the space for heating is doubled, the heating capacity of the furnace is increased about 50 per cent. and the efficiency of the furnace is increased correspondingly. The steel also is heated more slowly.

The type of burner now furnished with this furnace is suitable for either high or low pressure air. It has merely to be throttled for high pressures, and when this is done, it is as efficient as burners designed especially for high pressures and eliminates the noise common to such burners.

This furnace burns petroleum or any of its oils, such as gasoline, kerosene, distillate, etc.

Oil heating has many advantages. The steel cannot be injured by absorbing injurious elements such as sulphur, phosphorus, or other impurities which are present in nearly all coals, nor from unequal heating, as the steel is heated in a flame which gives a uniform temperature. The steel is in full view of the operator at all times. The absence of smoke, soot, dust, ashes and cinders is a great convenience, particularly appreciated in underground mine installations and in plants installed in buildings. The floor space occupied by the No. 3 furnace is 3 by 4 feet. No foundation is required, installation being complete when the air and the oil supply pipes are connected.

Made by the Ingersoll-Rand Company, 11 Broadway, New York.



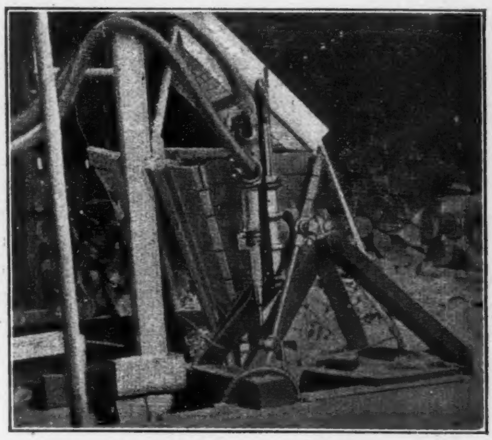
PNEUMATIC SPRING BANDING PRESS

The halftone above shows a heavy press for closing the centre bands upon standard leaf springs for railroad service, a recent addition to the machinery line of Joseph T. Ryerson & Sons, Chicago. As will be seen there are two plungers, horizontal and vertical, actuated through powerful leverage from two 16 in. air cylinders. The movements and the ultimate pressure, which may go as high as 60 tons, are controlled by three-way valves connected with each cylinder. The ordinary shop supply air pressure is sufficient, and, on account of the infrequency of action, the air consumption is small. The machine weighs 6,500 lb.

FOR BETTER TUNNEL PHOTOGRAPHS

Tunnel photos usually taken by or for contractors, as records of progress and for other purposes, are generally more or less unsatisfactory on account of the lighting conditions. Ordinary flashlights give only local illumination and the distant portions included in the view are not clearly defined. A tunnel photo of unusual detail and clearness was taken under the direction of Mr. S. P. Brown, chief engineer of the Mount Royal Tunnel & Terminal Company, Montreal.

When taking the picture after the camera had been set and the lens uncovered, a man with a magnesium blow-torch mounted in front of a large screen was ordered to walk through the tunnel in front of and away from the camera, thus illuminating the bore for a long distance without any of the direct rays fogging the plate. This seems to be an excellent scheme, where it is possible to use it.



AN ELECTRIC-AIR-DRILL STAMP MILL

Many a mine superintendent has felt the need of a more thorough method of prospecting orebodies he is opening than by the assaying and panning of marked samples, before it is advisable to build even a small mill of the regular type. This need has been met by the South Fork Gold Mining Co., at Forest, Sierra county, California, in the following manner. The company had purchased a Temple-Ingersoll electric air-drill, for the purpose of extending the hard-rock tunnel for gravel, and did 400 ft. of work along that line. Since then attention has been given to

developing one of the lodes where the rock is not hard or solid enough to stand a power-drill. The drill not being in use, it was thought that it could be made serviceable as a one-stamp mill; on account of the heavy blow that it strikes and because of the low cost of operation, it has answered the purpose exceptionally well. Working in this capacity, the drill uses 2½ hp. and crushes a ton of hard quartz through a No. 1 screen in 14 hours, striking 220 times per minute with the motor operating at half-speed, which is not the regulation rate, but the motor does not show any ill effect of continuously running at half speed. The drill is mounted on a tripod that in turn is held by heavy timbers, which are anchored to the solid rock. —*Mining Press.*

THE NOISE OF A BULLET

A person in the line of fire of a modern gun hears distinctly two successive detonations. According to his distance these may be close together or farther apart, and they may or may not be accompanied by a continued whistling or roaring sound. The two noises, as is noted by Col. Agnus, of the French army, in the *Revue Scientifique* (Paris), are familiar to target-keepers in rifle matches, who usually suppose them to be caused respectively by the discharge of the gun and the impact of the bullet on the target or the ground. This is incorrect. Col. Agnus tells us that the first noise is the discharge, but the second is due to disturbance of the air by the bullet. When the projectile starts, it is moving faster than sound. It slows down, and when it has gone about a mile and a half the sound-wave begins to gain on it and finally passes it. To these facts are due the phenomena of the bullet's noise, as is shown by Col. Agnus in a mathematical analysis. In the first place, the two noises will be heard only with modern high-powered weapons, whose bullets move faster than sound. If the observer is nearer than about 300 feet the two sounds merge into one. Farther away they are heard farther and farther apart, and at about a mile and a half, the point where the velocity slows down to that of sound, a continuous whistle or roar is heard, first between the two detonations and farther away, lasting longer and longer. Of course, if the projectile is a shell, its subsequent explosion adds other noises.

GIVING DRILL-STEEL A REST

BY CARROLL M. CARTER

Steel experiments, at the Carter Mining Co., Ohio City, Colo., proved of great service in reducing breakage to a minimum. It came about in this way: We were short of steel and noticed that the breakage seemed to be more than usual just at a time when we could stand it least. Acting on this hint, we took a new piece of steel, put a Leyner shank and bit on it and sent it into the mine to start a drill hole. Immediately after the hole was started, the bit was brought out and resharpened and sent in to start another hole. This process was kept up until the steel jumped in two when starting the 12th hole. Another piece of steel handled in the same manner, but in somewhat softer rock, started 16 holes before breaking. Then another new piece of steel was sent in to start a hole and afterward allowed to lie idle for three days, when it started another hole. Four pieces of steel were used in these experiments, and by being permitted to rest as stated, they started, averaging the four, 51 holes each before breaking. We now have on hand three times the amount of steel needed in any one day and use one-third of it every third day and have next to no breakage.—*Eng. and Min. Journal*

A RAILROAD DITCHER AND GRADER

The Bowman ditcher and grader, shown in the accompanying halftones, is rigged for four kinds of work on railroad lines: excavating side ditches, plowing hard material, spreading dumped material and dressing the slopes of cuts. The apparatus it carries is duplicated and identical on both sides of the car so that it works on either or both sides of the track, as may be required. All operations on the machine are controlled by compressed air which is stored in large vertical receivers charged to 100 lb. pressure by three air brake pumps. As the ditcher is always accompanied by a locomotive it supplies the steam required.

The 50 ft. flat steel car carries two steel gallows-frames each supporting two jet cranes with 4 yd. scraper buckets suspended by a bail with operating chains running to two vertical air cylinders. The larger cylinder, 24 by 60 in., operates the hoisting chains, while the smaller cylinder, 12 by 60 in., operates

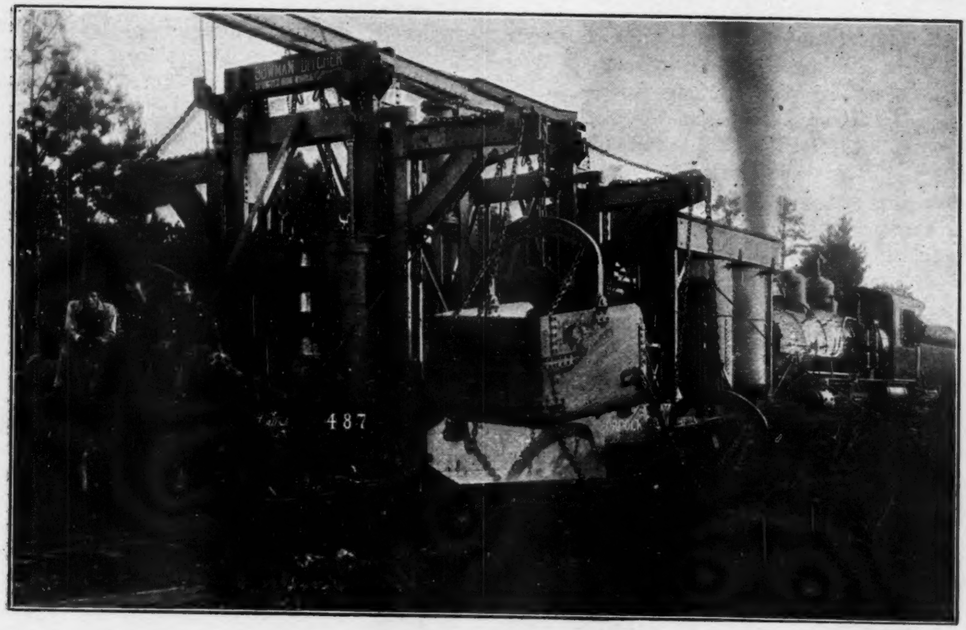


FIG. 1.

FIG. 2.

the dumping chain attached to the rear of the buckets. With the machine in place for ditching, as in Fig. 1, the forward bucket on each side is lowered and the locomotive pulls ahead slowly. When the buckets are loaded, taking in soft material about 5 cu. yd. each, they are swung up and the rear buckets are lowered and loaded in the same way. The machine is then hauled to the dumping ground and returned at once to load up again.

For spreading material dumped along the track on fills or in yards there is a scraper blade hinged to the side of the car, as seen under the rear bucket in Fig. 1. Where the material is too hard for excavating directly by the buckets, or where hard material is to be loosened for widening the roadbed beyond the reach of the bucket, the machine handles a heavy plow, as seen in Fig. 2. This plow is raised or lowered by a side tipping movement, the lever connecting with the piston rod of the horizontal air cylinder on the rear of the car.

For dressing slopes or widening cuts there is a scraper attached to a pair of telescoping struts, as shown in Fig. 3. The scraper is also used to form a shoulder for the ballast.

Fig. 4 is a view of the suspended buckets from the front.

The machine requires a crew of three men besides those on the locomotive. It has been used continuously as here shown with complete satisfaction on the Norfolk Southern R. R. Machines of this make have been used also by the Southern Pacific Co. and the Missouri, Kansas & Texas Ry. with uniformly good results. On the Southern Pacific the ditcher in a single month handled 22,320 cu. yd., in 8,650 ft. of ditch, at a cost of about 6½c. per yard., to which was added 3½c. per yd. for the work of shifting signals and cattle guards, dressing the ballast and trimming the ditches, and carrying them away from the ends of the cuts. In 18 months this machine averaged 8,720 cu. yd. per month, at a cost of 15c. per yd., 20c. including repairs and the miscellaneous work mentioned above.

The last machine of this type built for the Norfolk & Southern operated in the month of November, 1915, over a length of 75 miles cleaning out and widening shallow cuts and distributing material, which entailed a great many different moves. The average yardage per day was 486; average distance hauled 1,886 ft.; average cost per yard, 7.6c. Maximum yardage for a single day, 912.

The ditcher was invented by Benjamin Bowman, Springfield, Mo., and is sold by the T. W. Snow Construction Company, Ellsworth Building Chicago.

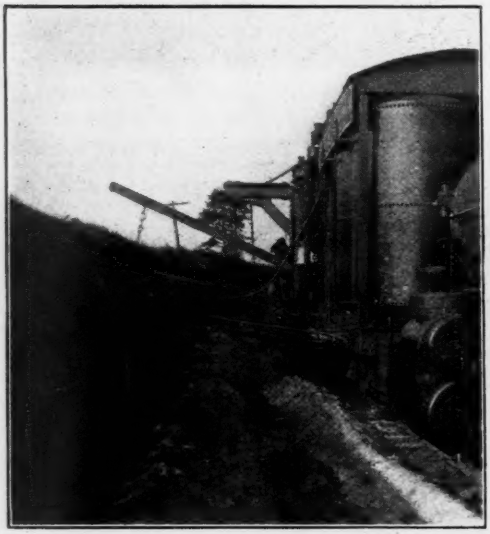


FIG. 3.

FIG. 4.

A TUNNEL RECORD IN THE COURTS

J. A. McIlwee & Sons, engineers and tunnel contractors have received a verdict for $800,000 against the Canadian Pacific railroad in the court of appeals of the Dominion of Canada. The railroad has taken the case to the law lords of the English privy council (which is the court of last resorts in the British empire), but it is certain that the law lords will uphold the decision of the court of appeals and that McIlwee & Sons will collect.

The facts are that, Dec. 18, 1913, McIlwee & Sons entered into a contract with the railroad to drive a five-mile railroad tunnel through the Selkirk mountains in British Columbia. In addition to the price for the work, the Canadian Pacific agreed to pay the contractors a bonus of $1,000 for every foot of the tunnel bored each month, from each end, in excess of 900 feet. The formation in that part of the Selkirk was known to be very difficult, and it did not seem probable that McIlwee & Sons would be able to earn a cent of that bonus. It was, indeed, doubted whether they could live up to their contract in the matter of the maximum time allowed for finishing the job.

But McIlwee & Sons, instead of falling down on their contract, worked so far ahead of it in the rapidity of their bore, that, in nine months' time, the Canadian Pacific railroad owed them $215,000 for bonuses. The contractors had, in fact, maintained their minimum of 900 feet a month from each end of the tunnel and 215 feet in addition.

However, when the Canadian Pacific railroad realized that McIlwee & Sons seemed likely to pile up about $1,000,000 in bonuses, it started raising all kinds of artificial difficulties to retard the work. In spite of these difficulties, McIlwee & Sons kept on with the work, earning more bonuses all the time. Then, as a last resort and in order to save themselves the payment of the bonuses, the Canadian Pacific raised some fictitious quarrel and canceled the contract. Forthwith McIlwee & Sons filed suit against the Canadian Pacific in the supreme court of British Columbia for breach of contract and for the bonuses then due. They were awarded $527,000.

The Canadian Pacific appealed the decision and award to the court of appeals of the dominion. That court not only upheld the award in favor of McIlwee & Sons, but increased it to $800,000.—*Mining American.*

LIMITS OF WORKING TEMPERATURE IN MINES

In the report of the Royal Commission on Mining Industry at Broken Hill, (Australia), a section is devoted to the question of the possibility of the reduction of temperature to 75 degs. Fahr., or, if this should prove impracticable, a reduction in the hours of work in proportion to the temperature. The Commission considered the question of what constitutes a high temperature. In Queensland, a Royal Commission had previously recommended a degree of humidity represented by a dry bulb temperature of 85 degs. Fahr. and 80 degs. Fahr. wet bulb. If the dry bulb temperature exceeds 85 degs. Fahr., the wet bulb must be at least 7 degs. less. In Western Australia the standard is 87 degs. Fahr. dry and 80 degs. Fahr. wet. In Victoria 83 degs. Fahr. wet bulb, and in New Zealand 80 degs. Fahr. wet bulb. In Great Britain the Royal Commission on Mines, 1909, refused to fix a standard, but Dr. Haldane has stated that for the economical working of a mine the wet bulb temperature should not be allowed to rise above 81 degs. Fahr., unless perhaps where there is a good ventilation current. The present report discusses the various causes of high temperatures in mines, which are due to:—(1) The progressive increase of temperature with depth; (2) the oxidation of minerals; (3) the warming influence of men, animals and lights; (4) explosives; (5) the incoming air during the summer months; (6) rise of temperature due to increased barometric pressure, amounting to 1 deg. Fahr. in 180 ft. It appears that in New South Wales there is a seasonal variation of underground temperature amounting to 3 degs. Fahr., but this would probably be overcome by improved ventilation. The hot places in a mine are always the dead ends, and it generally happens that the hottest places are those in which it is necessary to use water to keep down the dust, which keeps the air moist and raises the wet bulb temperature. The Commission has come to the conclusion that a standard should be fixed of 82 degs. Fahr., wet bulb, but a minority report recommends 78 degs. Fahr. wet bulb.

AN UNUSUAL AIR LIFT INSTALLATION

The interesting air lift plant here to be described has been installed for supplying the Transcontinental Railway yards at the Quebec Bridge. The neighborhood of the magnificent St. Lawrence would seem to be an anomalous location, but several considerations operated to determine the installation. The rise and fall of the tide, the height of the embankment and the unsuitability of the river water were important points, and besides this the use of the river water would have necessitated the construction of a pumping plant at a distance from the power house, and would have increased the cost of attendance.

Work was started in September, 1912. Forty-three feet of 8 in. wrought iron pipe was driven from the surface to the rock, and from that point a 5-in. bore hole was started. The well was drilled entirely in shale, red and gray alternating.

On September 30th a depth of 400 ft. had been reached, and a rough pumping test yielded 200 imp. gal. per hour. At 280, 520 and 700 ft., respectively, dry crevices were encountered, while at 775 feet water was struck in considerable quantity. The hole was then reamed to a diameter of 8-in., and a subsequent test yielded 3,200 imp. gal. per hour.

At a depth of 980 ft. another water crevice was opened up and at a depth of 1,012 ft. drilling was discontinued. The whole well was then reamed out to 8-in. diameter. A large plunger pump was used for a 24-hour test, and with 400 ft. of rods in the well a yield of 5,400 imp. gal. per hour was maintained. This pump was afterwards operated for eight days to clean out the well, and a sample of water was analyzed and reported satisfactory for both boiler and domestic purposes.

When the well is not being pumped water rises to the surface; when being pumped to capacity it drops, however, to a depth of 400 ft. from the surface.

A joint contract was awarded to Canadian Ingersoll-Rand Co., Limited, and Williams and Wilson, Limited, of Montreal, for furnishing and installing a suitable pumping plant. The air-lift system was adopted owing to its numerous advantages over other systems of deep-well pumping, as with this system there are no moving or wearing parts in the water, and the air-compressor may be located at any distance from the well.

In lowering the pipes and foot-piece, which were extra heavy, great care was required because of the weight; but there was no mishap of any kind.

The air-compressor is a Canadian Ingersoll-Rand tandem compound steam-driven machine, designed for a terminal pressure of 250 pounds, and the air cylinders are fitted with a new type of valve known as the circo-leaf valve, which is absolutely noiseless in operation. The frame is fully enclosed, and the moving parts work in a constant flood of oil. A combined speed and pressure governor controls the compressor.

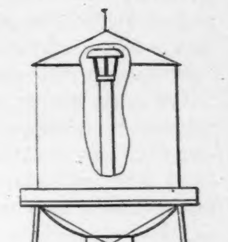
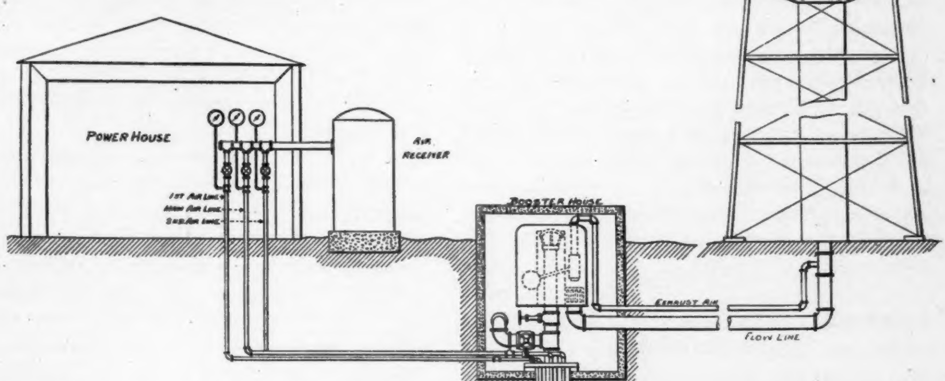
The air-lift foot-piece was manufactured by the Harris Air Pump Co., of Indianapolis, whose pumps are extensively installed throughout Canada. The column of water is carried by an air-jet situated below a choker, which arrangement eliminates slippage and causes the air to be distributed through the water in small bubbles. The booster pump was also furnished by the same firm.

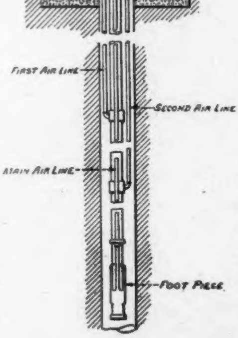
Water is discharged into a steel tank 24 ft. in diameter, and the total capacity, including the leg, is 61,170 imp. gal. The level of the water in feet is indicated by a marker on the outside of the tank, and by this means it is possible to accurately gauge the capacity of the plant. The tank is supported by a steel frame resting on a concrete base, in which are located the valves and connections to the service mains and to the main drain. Steam is furnished to the compressor at 110 lbs. pressure.

Owing to the depth to which the water drops in the well three air lines are used, two being tapped into the water discharge line at different depths, and the third entering the Harris foot-piece. Each of these three air lines is controlled by a gate-valve in the power-house, and the engineer operates the system without going near the well, which is 250 ft. from the power-house. A gauge over each line shows the pressure and indicates the fall of the water in the well.

Air discharges from the compressor into a high-pressure air-receiver and from there to the well. The first air line starts the water flowing and continues to pump until the well

lowers as far as this line is capable of lowering it. Then the first air line is gradually turned off until the second line begins to act. When this line has lowered the water as far as it is capable of lowering it the work is taken up by the third line and the second line is closed. The third line, which is the main pump line, then continues to furnish air as long as the system is in operation.



AIR LIFT INSTALLATION AT QUEBEC BRIDGE.

The object of the first two lines is to enable the accumulation of water in the well to be pumped away without resorting to an abnormally high air pressure. These lines are only used in starting the system.

The yield of the well is 5,400 imp. gal. per hour delivered into the tank, and under continuous operation the air pressure at the receiver is about 160 lbs. When the system is first started the yield reaches a total of about 6,000 imp. gal. per hour, this being due to the accumulation of water filling the well to the surface. The yield gradually decreases under continuous operation until the normal capacity and pumping head are reached.

At the surface the water has to be pumped horizontally a distance of 60 ft., and subsequently to a height of 90 ft. into the top of the steel tank. For this work a Harris booster operates in conjunction with the air-lift.

This booster consists of a steel tank resting on the top of the well-casing and receiving the water as it discharges from the well. The operating parts consist of a float and valve located inside the tank. The water and air are separated in this tank, the air rising to the top and maintaining sufficient pressure to force the water to the elevated tank. As the solid column of water discharges the float drops, allowing the surplus air to exhaust from the tank. This whole operation requires only a few seconds, as a discharge takes place every time the booster is about two-thirds full. In fact, practically a constant flow is maintained.

The surplus air may be piped back to the compressor intake or discharged into the vertical riser to lighten the column of water and reduce the operating pressure. This latter plan was followed in the case of the plant at Quebec. The booster is automatic in operation and requires no attention. It also operates without noise. This apparatus is located in a concrete sump below the ground and is reached through a door in the roof. A by-pass is connected to the main drain so that the well can be pumped directly into the sewer for cleaning purposes.

The plant was operated by the contractor for several days under the supervision of

Mr. Alex. Porter, Assistant Engineer of the Transcontinental Railway, who at the completion of the test said the plant was entirely satisfactory, and the most reliable of the various railway divisional pumping units.

The high lift in this case is a noticeable feature, amounting to about 500 ft. vertical and 60 ft. horizontal. It demonstrates as far as it goes that there is practically no limit to the height to which the air lift will raise water if a fair amount of submergence is obtainable.

On a test recently the plant pumped nearly 6,000 gal. (Temp.) per hr., but this capacity was due to accumulated water near the well. The normal capacity (5,000 gal. per hr.) was developed continuously after the level dropped to 400 ft. At this point the running pressure was 160 lb. per sq. in. The highest pressure required for starting was 225 lb.

TURBO-BLOWERS AND TURBO-COMPRESSORS*

Basically considered, turbo-blowers and turbo-compressors are similar machines, only that the former are used for low pressures and the latter for high pressures. Both classes of machines are therefore constructively different with reference to the number of stages and the delivery volume. Usually the turbo-blowers and compressors of today are built on the principle of the centrifugal pump—that is, the gas to be compressed is conducted in radial paths. Among the few designs that depart from this arrangement is the Parsons, in which the flow direction, as in steam turbines, is axial.

It is difficult to define the boundary between turbo-blowers and turbo-compressors. All turbo machines used to supplant reciprocating blowers should be called turbo-blowers.

The pressures vary between 0.3 and 3 atmospheres, according as the blower is used for blast furnaces or for bessemer converters. Under normal operation blast-furnace bloweres are run under 0.3 to 0.75 atmosphere; at times double that, and the delivery volume varies greatly; while in the case of the converter blast the pressure is about 3 atmospheres and the delivery volume is approximately constant.

The capacities of turbo-blowers for blast furnaces run from 1,000,000 to 3,500,000 cu.ft. an hr., steelworks having a lower figure, or up to about 1,750,000 cu.ft. per hr. Turbo-compressors have, in general, a lower capacity, say up to 1,250,000 cu.ft. per hr., but must thus attain considerably higher pressures, 6 to 10 atmospheres. Occasionally higher capacities are reached, as in the case of three turbo-compressors recently built by the Allgemeine Elektricitäts Gesellschaft, each of which has a capacity of a little less than 3,000,000 cu.ft. of air per hr. compressed to 8 atmospheres.

In the choice of a driving medium it must be kept in mind what is to be expected of the blower or compressor in the way of regulation of the capacity and pressure. In general it can be said that where great capacity fluctuations obtain, as in the case of blast-furnace blowers, the preference is for the steam turbine, whereas with constant capacity the high-speed electric motor is used. In relatively small plants the steam turbine is used almost exclusively, as with the fixed-speed electric motor. Under such circumstances the number of stages can be kept down and thus decidedly affect the design, as the construction cost is almost proportional to the number of stages.

Essentially the design of the Allgemeine Elektricitäts Gesellschaft turbo-blowers and turbo-compressors is a series of consecutively placed bucket wheels, the number depending on the desired final pressure and the kind of gas to be compressed. It varies between 1 and 26, up to 14 being usually on one shaft, and where a greater number is called for two compressors are arranged in tandem.

Notwithstanding the water-cooled housing of the turbo-machines, the temperature rise of the gas from, say, 70 deg. F. can extend to 212 deg. Although in the later stages this phenomenon is much less in evidence, to the end that the compression finally is even closely isothermic, the total thermal efficiency is nevertheless injuriously affected thereby; so that in this respect the turbo-compressor has not so far come up to the reciprocating one.

As a general conclusion it can be said that in the first stages the cooling effect is not

Continued on page 7931.

*O. H. Wunderlich in *"Zeitscrift des Vereines deutscher Ingenieure."*

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COMPRESSED AIR MAY SAVE A PARK

The public parks of New York, and especially the smaller or neighborhood parks, are among its most valued possessions, and permanent encroachment upon or curtailment of them invariably provokes popular protest. At the present time a large pumping station for the New York City aqueduct of the new Catskill system is being erected upon a small lawn which is an important feature of Morningside Park, constituting a great disfigurement and a practical destruction of an attractive section of this valued resting place, and and much popular indignation is expressed.

As to the urgent and immediate necessity for this pumping station there can be no question. When water has been admitted to the new aqueduct, and it has been subjected to the full service pressure, it will be necessary to shut off the pressure and to pump out the water, so that the aqueduct may be examined from the interior for the detection of leaks or weaknesses or imperfections of any kind. After two or three such pumpings-out, if the aqueduct was decided to be in satisfactory condition, the services of the pump might not be required again for many years, but it would be necessary to maintain it constantly ready for immediate use in case a break in the aqueduct should occur, or any accident requiring the unwatering of the tube.

On the Croton aqueducts, either the old or the new, there was no requirement for any such unwatering plant, because the lines were carried so high that they could all be drained by gravity. The one exception to this was the siphon of the new aqueduct which passes under the Harlem River at a great depth, and for the unwatering of this a permanent installation was provided and is maintained in constant readiness, although it has not been called upon in a score of years. In the first arrangement for this service there was an enormous bucket to be successively raised and lowered in the shaft, but this was replaced by a return-air pumping apparatus which will do the work in half the time.

Now, as to the Morningside Park pumping station here under discussion, it happens that just in this neighborhood is the lowest spot in this section of the city aqueduct, so that the precise location selected may be presumably the best, and the pumping devices decided upon also may promise the most satisfactory re-

sults, all of course without thinking at all of any outside conditions. When these assert themselves and call for a compromise in the arrangements, it cannot be denied that there are other ways of doing this thing which would be less objectionable, and these should at least be carefully considered.

This matter is being variously discussed in current issues of the daily press. The following is from an interview with W. L. Saunders, retiring President of the American Institute of Mining Engineers, in the New York Times, Feb. 13, 1916:

I hesitate, said he, to speak for publication on this matter, because I have a high regard for the Engineer in Chief of the Board of Water Supply, and I have no doubt he has given this question much study. From the point of view of absolute economy and efficiency the Board of Water Supply may have much on its side. Are there not other considerations, however, in a question of this kind? There are aesthetic reasons why the matter should be discussed from a new angle. The putting of a structure forty feet high in Morningside Park is not justified. All citizens should interest themselves in seeing that it is not done. I never look at that unsightly pile, the Post Office Building, without thinking how public spirit years ago might have saved a large part of City Hall Park. The Board of Water Supply has a shaft in Morningside Park and proposes to establish a pump there for drawing the water out of a portion of the tunnel in case of emergency. Tunnels like this are often unwatered for repairs. There are several ways of doing this, as the Board of Water Supply itself has admitted, such as forcing the water out with compressed air, using automatic bailing devices, employing pumps in separate shafts, using mine sinking pumps, and lastly the device which was adopted by the board's engineers, a pumping equipment on a float with which the water could be followed down the shaft. The board adopted this last device as being, in its opinion, the most suitable for the problem in hand and on account of the minimum amount of machinery required and the minimum cost of masonry. The common ways of unwatering tunnels and shafts, where the work is done intermittently, is to use large centrifugal pumps, or, where conditions warrant it, to discharge the water by compressed air. The advantage of this system is that it will expel a large volume of water in proportion to the size of the plant required.

I see no reason why any of the systems could not be applied in this case. The compressed air lift plan could be used with advantage. The compressors need not be in the park, and, indeed, they might be at a considerable distance. It would be possible to put a sufficient plant in some cellar half a mile away and conduct the compressed air to the shaft by pipe. The air is forced down into the water through a tube, and starts the flow of water through another pipe which emerges at the top of the shaft.

By compressed air water can be lifted 2,000 feet by relays. Here the tunnel is less than 500 feet below the surface.

Louis Freidman, of Muncie, Ind., who recently purchased three discarded gas pumping stations near Fairmount, Ind., from the Indiana Natural Gas & Oil Co. estimates the iron and steel secured in the deal will aggregate about 480 car loads, and will require several months time to clean up and market. At the Fowlerton station there are 27 big gas compressors, each weighing about 35 tons.

It has been found in sounding the depths of the ocean that the temperature steadily decreases during the first 600 fathoms. When depths of 2 miles are reached the water approaches the freezing point. The depths of the ocean, even at the equator, register near 35 degrees. If some ingenious individual in the tropics will devise a method of sinking perishable foods into the depths of the ocean he will find a cold storage plant of unlimited capacity at his disposal.

Oxy-acetylene cutting played an important part in the dismantling and removal of fourteen large boilers at the plant of the Union Electric Light & Power Company, St. Louis, Mo. Each boiler was 11 feet in diameter by 21 feet long. The oxy-acetylene blowpipe permitted the cutting up of the boilers into small sections, such as could be easily removed without the necessity of tearing down a part of the building. The portable type of outfit was used, employing compressed oxygen and Prest-O-Lite gas. The cutting outfit was moved from boiler to boiler as the work progressed.

Continued from page 7928.

noticeable, but that in the last stages it is very good. The ultimate air temperature reached in the Allgemeine Elektricitäts Gesellschaft compressors under pressures from 85 to 115 lb. is about 167 deg. F. or less, depending on the temperature of the cooling water. The requirement of the latter with a 1000-hp. compressor at the foregoing pressures, for instance, amounts to about 1600 cu.ft. an hour, and increases approximately with the output.

As to the best speed, the rule is to give the smaller machines the highest possible, namely, 4000 to 5000 r.p.m., and the larger ones about 3000 to 3800.

As a minimum size the Allgemeine Elektricitäts Gesellschaft does not advise anything lower than 140,000 cu.ft. per hr. at from 70 to 85 lb. pressure for compressors and 35,000 ft. at about 20 lb. for blowers. These values might be taken as critical points, whereon the use of the reciprocating type in comparison with the turbine type would seem to be the more advantageous.

The wheels of the Allgemeine Elektricitäts Gesellschaft machines are made up of two nickel-steel disks between which the wrought-iron buckets are radially riveted. As to wheel diameters, in the case of the 3000-r.p.m. machine it is about 40 in., and decreases toward the pressure side, corresponding to the gradually smaller specific volume of the gas being compressed. For constructive reasons this decrease of diameter is not from wheel to wheel but from one group of wheels to another group, a number of similar wheels being assembled to form a group.

The Frankfurter Maschinenbau Allgemeine Gesellschaft builds steam-driven turbine compressors for outputs from 100,000 cu.ft. an hour up, and electrically driven at a minimum of 3,000 r.p.m. from about 200,000 ft. up, while for turbine blowers the output is from 70,000 ft. hourly for pressures up to 40 in. of water.

In line with the belief of this concern in the least number of wheels, it is today compressing to 7 atmospheres with 12 wheels. The buckets in these last are not radially disposed as in the Allgemeine Elektricitäts Gesellschaft machines, but suggest the spiral in their arrangement.

The Frankfurter Maschinenbau Allgemeine Gesellschaft has turned out a steam-turbine-driven turbo-compressor with a free-air capacity of over 350,000 cu.ft. per hr. to 7 atmospheres and with a horsepower requirement of 1150.

The Gutehoffnungshütte builds a turbo-compressor for from 425,000 to 635,000 cu.ft. of free air an hour compressed to 7 atmospheres. The average speed is about 3800 r.p.m. The same concern also makes a three-stage turbo-blower without water cooling. The capacity is from 600,000 to 700,000 cu.ft. of free air an hour compressed to between 7 and 8.5 lb.

THE STATUS OF NATURAL GAS COMPRESSORS

The art of natural-gas compressing is now over 25 years old, and has grown at practically the same rate as the increase in domestic natural-gas consumers. There are now over 200 natural-gas compressing stations in North America, aggregating more than 320,000 hp. of compressor capacity and representing a property value of more than $22,000,000, and compressing more than 85 per cent. of all the gas used. The age and magnitude of the art make it evident that the use of gas compressors is a recognized integral part and universal custom of the natural-gas business.

The public also is not without its rights and vital interests in this problem. Approximately 1,700,000 domestic natural-gas consumers in North America are dependent upon gas compressors for their natural-gas service. That is, if the use of compressors were to be prohibited, the majority of these consumers would be unable to secure adequate natural-gas service.

Each consumer represents between four and five persons, and it therefore follows that the comfort and well-being—as far as natural-gas service is concerned—of at least 8,000,000 persons would be affected if the use of natural-gas compressors should be prohibited. These 1,700,000 consumers have invested, in services, house piping, fixtures, and appliances, an average of about $90 each, or an aggregate of $153,000,000, which is much more than the companies' investment in gas compressors. Furthermore, in all cases where the rate paid by the consumers is fair to the gas company—considering the value of the service rendered by the gas com-

pany—the consumers are entitled to continued service and protection of the investment they have made on the faith that the gas service would be continued in the future.

Since "Customs adopted and acquiesced in, if not in conflict with federal or State legislation, have the force of positive law," and "Courts will take notice of whatever ought to be generally known within the limits of their jurisdiction," there ought to be no question as to the unqualified right to use gas compressors. However, many small gas-producers, not using gas compressors, have sought to secure permanent injunctions from courts to prevent other gas-producers from using such compressors. This has resulted in much expensive litigation.

The above is the introductory portion of a paper prepared by Samuel S. Myer, Columbus, Ohio, for presentation at the February meeting of the American Institute of Mining Engineers. The paper is a valuable chronological arrangement of all the court decisions relating to this important topic from 1885 to 1913.

AIR IN COMPRESSION AND EXPANSION

BY C. K. BENNETT.

In the compression of air all the work done is converted into heat and shows itself in the temperature of the compressed air. The accompanying chart* is based on air at atmospheric pressure and an initial temperature of 60 deg. The curves marked 1.41, 1.35 and 1.25 are plotted for the given exponents representing the ratio $Cp \div Cv = K$, and express the ratio of specific heat at constant pressure and constant volume.

When air is compressed adiabatically, all of the heat resulting from the compression is retained in it and the exponent of the curve is 1.41. For example: Adiabatic compression from 14.7 lb. absolute and 60 deg. F. to 200 lb. absolute. It will be seen by reading to the left from where the 200-lb. vertical line intersects the curve marked 1.41, that the temperature of the air after the compression is 651 deg., and by reading from the same point radially to the volume at the top, it will be found that one cu.ft. of free air when compressed under the conditions mentioned will equal 0.157 cu.ft. By reading again from the same point horizontally to the right (200 lb. on the 1.41 curve) it will be seen that there will be 64,200 B.t.u. given up to the air per hour, when compressing 100 cu.ft. of free air per minute.

Cooling the air during compression by the injection of water, radiation, etc., alters the value of the exponent curves *K* and therefore various curves of exponents are plotted, by means of which the temperatures, volumes and B.t.u. may be found for any condition.

A compression curve with an exponent of 1.25 is the best result that was obtained at Quai De La Gare, Paris, in a single-cylinder compressor cooled with a very fine spray of water.

In addition to the volume and temperature, the theoretical horsepower required to compress the air may be found from the B.t.u. per hour for compressing 100 cu.ft. per min. to the desired pressure, and taking the same relative part of these B.t.u. as the number of cu.ft. that is desired to be compressed is of 100, thus getting the correct number of B.t.u. for the given amount of air at the given pressure. The B.t.u. found when divided by 2,545 will give the theoretical horsepower required; to which should be added the allowance for friction, clearance, etc., to correspond to the compressor under consideration. The final result will give the horsepower required to drive the compressor under the various conditions set forth.

The volume of 1 cu.ft. of free air after compression may be read directly, and by plotting all factors or values from the one curve, when the pressure line is followed up to the curve representing the exponent of compression and a pencil is held at that point, all factors can be read directly; that is, temperature, volume, B.t.u. (which by the way is a decided and valuable addition to the curve) and the horsepower required may be determined. The heat available for heating from the compressed-air transmission pipes can also be readily determined. *Power.*

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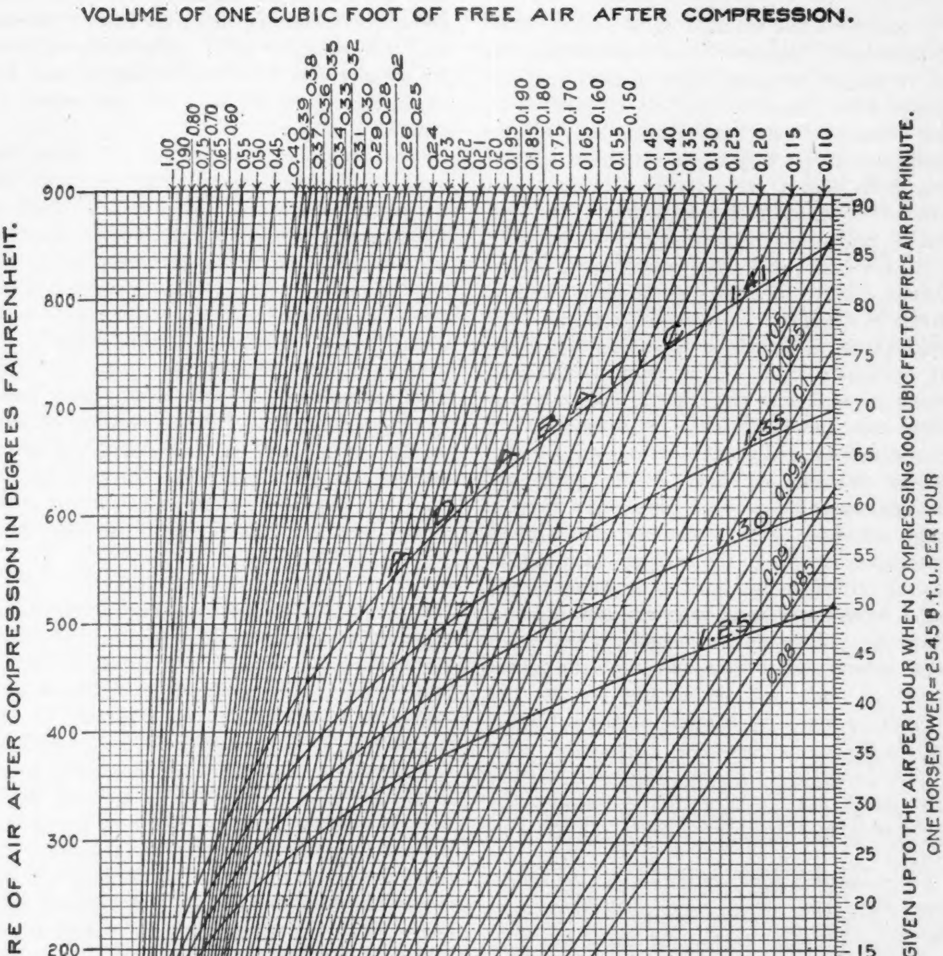
*Copies of this chart, 17x20 in., may be secured from C. K. Bennett, 1949 East Monmouth St., Philadelphia, Penn., for $1 each.



AIR IN COMPRESSION AND EXPANSION.

TEMPERING MINE DRILLS

BY HUGH SPOTTISWOOD.*

I was born and brought up in Alston Moor, Cumberland, England, where lead mining was the principal industry. The majority of the mines were owned by the Government London Lead Company, and throughout all the company's mines they had a system of tempering drills that I have never seen anywhere outside of that company's works. The system I will explain later on.

I have had about fifty years' experience in mining. After leaving home, I worked in mines in Canada, in some of the largest iron ore and copper mines on Lake Superior, State of Michigan, U. S. A., in copper and silver mines in Montana, U. S. A., in lead mines in Wisconsin and in Ohio, U. S. A., at Gympie in Qeensland, and (where I am at present) Mount Morgan. I have worked with the drilling machine almost since the time it came into use. I have seen the advancement and improvements in the drilling machine, and in the different ways of sharpening drills, but I have never once seen any advancement from the old system of tempering drills. It is a system which has sometimes been the cause of men not being able to do fair amount of work on account of the drills not getting the proper temper. There were times in the Mount Morgan Mine when the machine men could not do any boring, because the drills were as soft as lead, especially the long drills.

I remember a time, about sixteen or seventeen years ago, when every drill that came into the mine was so soft we could do nothing with it. I was working in a hard drive at the time. When the mining manager came into the drive to make some inquiries about the drills, and I was going to tell that I knew of a system of tempering that would do away with all soft drills, he would not listen to me. Some years after that time a change took place; there was a new manager, and some time afterwards we were having another run of soft drills. Someone told the manager something; he came to me in the mine, began to make enquiries about the drills, and I told him all I knew about the matter. He looked at some of the drills that we had been trying to drill with, and the bits were as blunt as the head of a hand drill that had been beaten with a hammer. I explained my system of tempering and also what I thought was the cause of those drills being so soft. He at once saw the force of what I said, and stated that he would have the new system installed right away.

It so happened that at that very time they were putting into the blacksmith's shop drill sharpening machines, and the first drills to come from the drill-sharpening machines were the first drills to be tempered by the new system. Though, the machine being new to the men, I can tell you there were some comical-looking bits turned out for a little while, but the temper was all right. Nineteen men out of every twenty were under the impression that the new system of tempering came along with the drill-sharpening machine, as they were both installed at one time, and the same system is still in use. Now I will describe what I think was the cause for the soft drills.

THE CAUSE OF SOFT DRILLS.

In the centre of the blacksmith's shop stood a big iron trough full of water, and drills were being put into it from all sides to temper. Now, fine muck and black sediment soon began to accumulate in the bottom of the trough. A large quantity soon accumulates —probably 10 in. or 1 ft. of fine muck, which is all the time in the bottom and the water on top. The drills are all the time going into the muck and staying there for a while. The muck got the biggest part of the heat. When it gets the heat it keeps it, and becomes very hot, though the water may be changed two or three times a day. The changing of the water makes very little difference unless the outlet be right at the bottom, and this does not often happen, because we generally see these troughs sunk a foot or eighteen inches in the ground. I have watched the blacksmith sharpening drills many a time, and often see him, after having got the drill sharpened, put it into the edge of the trough, with the bit about 2 in. into the water, holding it there for a second or two, and then letting it go right to the bottom of the trough, when the bit becomes buried in the hot mud. There it will stay probably two or three hours. Now, I am of the opinion that whatever temper that drill had, it got while the blacksmith was holding it and as soon as it

*Queensland, Australia.

went into the hot mud this hot mud took the temper out; and I think the reason why the longest drills were always the softest was because the longer the drill is the heavier it is, and it will sink the bit deeper in the mud.

Now I will describe the other system of tempering. The system is to have the bit of the drill when in the water stand on a clean surface—machine drills in about 2½ in. or 3 in. of water, hand drills in about 1½ or 2 in. of water, the water to come in at one end of trough and run out at the other end. In my country we would use a stone flag, 3 ft. by 2½ ft., but as stone flags are not to be had in this country a flat sheet will answer the purpose just the same. Now, we want a trough 3 ft. by 3 ft., and about 1 ft. in depth, made to hold water, and sink it 6 in. into the ground to make it steady; it must be properly level, so that the water will be uniform on the flat sheet.

Then, there should be a flat sheet 3 ft. by 2½ ft., or small enough to go inside the trough, with 6 in. of space between the front of the trough and the flat sheet; also four pieces of 4 by 4 hardwood, 2 ft. 6 in. long, one piece to be laid at each end of the trough and the other two pieces between them, to be laid on the bottom of the trough and the flat sheet laid on top of the four pieces, with the 6 in. of space to the front of the trough, with a pipe to come through the trough at one end about 5 or 6 in. above the flat sheet, and with a tap on it, so that the blacksmith can cut the water off when not in use. A hole should be cut through the trough, if for machine drills, about 2½ or 3 in. above the flat sheet. The outlet can be easily altered if found to be not right. The less water the harder will be the temper; the more water the softer the temper. Now, the drills have to stand upright with their bits in the water on the flat-sheet. It is necessary to have a sort of fence at the back and the two sides for the long drills to rest against. The 6 in. of space which is at the front of the trough, which is about 5 in. in depth, is to hold the muck which will accumulate on the flat, which should be swept with a broom every time it is clear of drills. The front part of the trough is also used for tempering picks and hammers.

Now that I have described the system as well as I can, it will be seen that it is easier for the blacksmith. All he has to do is to stand his drills on the flat sheet, one up against another, and leave them there and they will temper themselves. If a drill is set into the water with a white heat on it, it will be too hard and brittle, but that does not often happen. It is not only here that I have had trouble with drills tempered by the old system, but in a good many places where I have been, especially with machine drills. I think any big mining company that has large quantities of drills to handle, if they adopt the system which I have described, will have no cause to regret doing so. There is not much expense about it; the only drawback it has is that it takes a little more water than the other system.

NOTES

Experts agree that the gas well brought in recently by the Guffey Petroleum Co. on its White Point lease, seven miles from Corpus Christi, Texas, is the greatest producer in the world, the flow being estimated at 30,000,000 cubic feet daily. It is the third big gasser that has been brought in on the White Point tract within the past 15 months, two being brought in by the Guffey company.

Brazil has an area of 3,292,000 square miles, which is greater than the United States exclusive of Alaska, and a population of 24,000,000, which is one-quarter of that of the United States; Rio de Janeiro, the capital, has 1,500,000. Ocean-going steamers can ascend the Amazon to Manaos, which is farther inland than Chicago or St. Louis. Shipments of iron and steel, machinery and oils from the United States to Brazil are increasing rapidly.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JANUARY 4.

1,166,430. PNEUMATIC SHIFTING DEVICE FOR MOVABLE MEMBERS OF AN AUTOMATIC MUSICAL INSTRUMENT. CHARLES S. BURTON, Oak Park, Ill.

1,166,439. AIR-RELIEF VALVE FOR WATER-MAINS AND THE LIKE. JUSTUS N. CORBIN, Fruita, Colo.

1,166,455. PNEUMATIC ACTION FOR PIANO-PLAYERS. ARCHIE N. GRIMES, Chicago, Ill.

1,166,503. AIR-VALVE. CLAYTON WEAVER, Phalanx, Ohio.

1. In a motor vehicle the combination of a brake mechanism; a clutch mechanism; a rod for operating each of said mechanisms; manually controlled means for operating each of said rods; an air cylinder for said brake mechanism; an air cylinder for said clutch mechanism; a piston in each of said cylinders; means for admitting compressed air behind each of said pistons; and a sliding connection between each of said rods and said pistons adapted to permit the manual operation of said brake and clutch mechanisms without affecting said pistons and to also permit the operation of said brake and clutch mechanisms by admitting compressed air behind said pistons, substantially as described.

1,166,522. AIR-BRUSH. BIRCHARD E. HOLTON, Los Angeles, Cal.

1,166,659. CENTRIFUGAL FAN. WILLIS H. CARRIER, Buffalo, N. Y.

1,166,855. SAFETY DEVICE AGAINST EXPLOSIONS IN THE AIR-PIPES OF INTERNAL-COMBUSTION ENGINES. CONRAD C. REGENBOGEN, Kiel-Gaarden, and PAUL R. RITTER, Kield, Germany.

1,166,945. PNEUMATIC PRINTING FRAME. EMANUEL W. SWEIGARD, Chicago, Ill.

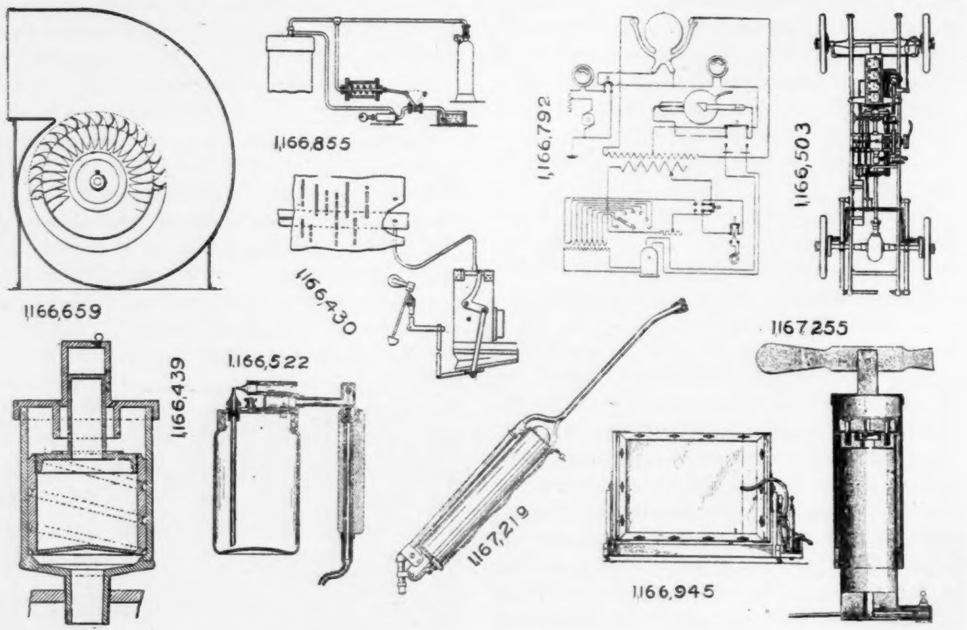
1,167,219. PORTABLE VACUUM-CLEANER. DANIEL BENSON REPLOGLE, Berkeley, Cal.

1,167,255. AIR-PUMP. ALVIN R. BERCK and FRED TJADEN, Hastings, Nebr.

JANUARY 11.

1,167,421. PRESSURE INDICATING AND REGULATING DEVICE. HENRY W. MAURER and FRED K. TAYLOR, Rochester, N. Y.

1,167,492. ART OF IMPREGNATING TIMBER AND OTHER POROUS MATERIAL WITH A PRESERVATIVE. OLIVER P. M. GOSS, Seattle, Wash.



PNEUMATIC PATENTS JANUARY 4.

1,166,719. FLUID-PRESSURE GAGE. JOSEPH SHEBOL and WILLIAM F. ALBRECHT, Syracuse, N. Y.

1,166,723. ATTACHMENT FOR PNEUMATIC MACHINE RIVETERS. WILEY STARK, Devils Slide, Utah.

1. As an article of manufacture, a tool for use on machine riveters, the tool presenting a head to be introduced between the riveter set and the work, and means independent of the said riveter set whereby said head may be held in position on the riveter in position for use.

1,166,792. EVACUATION PROCESS. HOMER CLYDE SNOOK, Cynwyd, Pa.

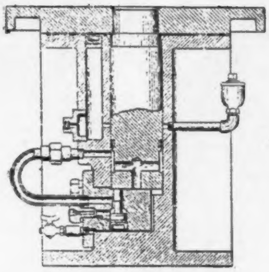
1. As an improvement in the art of exhausting bulbs, the method which consists in partially exhausting a bulb, passing energy through the remanent atmosphere between an anode and cathode, heating said cathode by said energy, and further exhausting said bulb during passage of energy until the cathode glow fills said bulb and acts upon the inner walls thereof.

1,166,854. PNEUMATIC WHEEL. JOSEPH O. RAYMOND, Concord, N. H.

1. In the preserving treatment of porous material, the method which consists in immersing the material in the preservative fluid contained in a closed container and then heating the fluid to approximately 230 degrees Fahrenheit, then emptying the container of the preserving fluid and drawing a vacuum therein of from 23 to 28 inches approximately and simultaneously heating the interior of the container to a temperature of from 150 to 230 degrees Fahrenheit, and continuing such treatment for upward of half an hour, then breaking the vacuum in the container by the re-introduction therein of the preserving fluid, then applying pressure to the fluid sufficient to force into the pores of each cubic foot of the material approximately five to twenty pounds of the fluid.

1,167,514. PNEUMATIC FLANGE-OILER FOR CAR-WHEELS. AUGUST W. OLSEN, Portland, Oreg.

1,167,511. JOLT RAMMING-MACHINE. EDGAR H. MUMFORD and EDWARD MELVILLE HUGGINS, Plainfield, N. J.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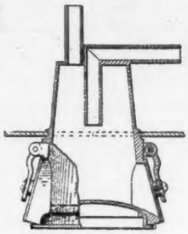
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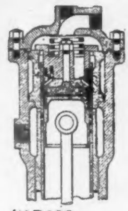
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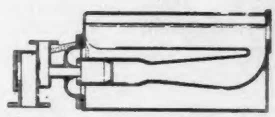
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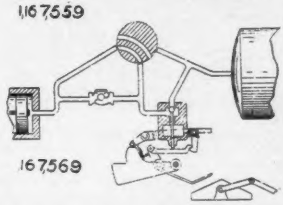
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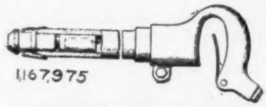
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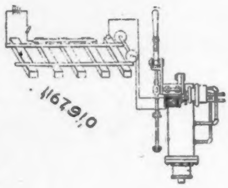
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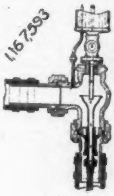
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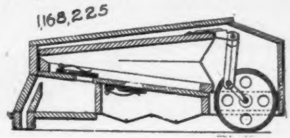
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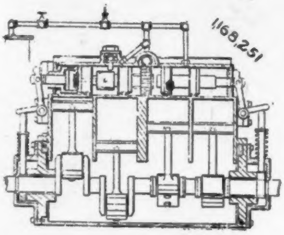
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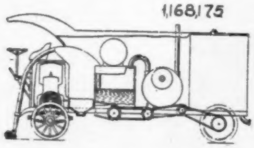
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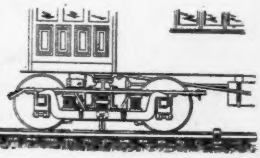

1,167,514

PNEUMATIC PATENTS JANUARY 11.

1,167,518. MANUFACTURING FROTH FILLINGS. FRITZ PFLEUMER, Dresden, Germany.

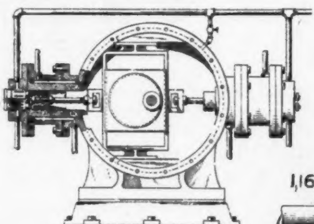
1. The process of manufacturing froth fillings which comprises the steps of vulcanizing vulcanizable material under a hot high gas pressure, then cooling the same under a cool gas pressure at least equal to the gas pressure applied during vulcanization, inserting the cooled filling into a casing, and then heating the filled casing to expand the filling until it occupies the interior of the casing.

1,167,559. HYDRAULIC DEVICE FOR COMPRESSING GASES. KENNETH GAULDIE, Glasgow, Scotland.

1,167,569. AUTOMATIC AIR-CONTROLLING DEVICE FOR VEHICLE-BRAKES. ELMER M. JONES, Atlanta, Ga.

1,167,593. AIR-PRESSURE LUBRICATOR. LEWIS G. O'DONNELL, Coscob, Conn.

1,167,658. HIGH-PRESSURE GAS-COMPRESSOR. EDWIN PRESTAGE, Stoke Newington, London, England.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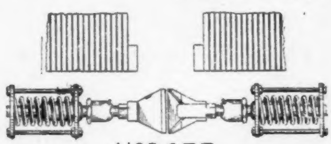
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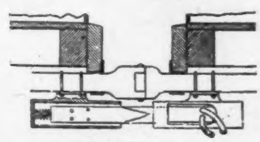
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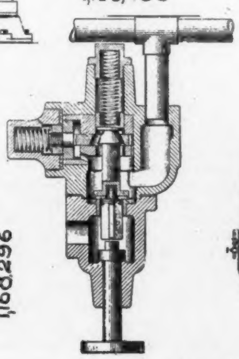
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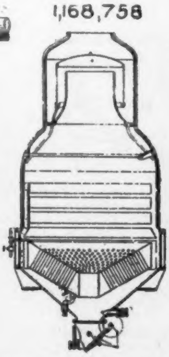
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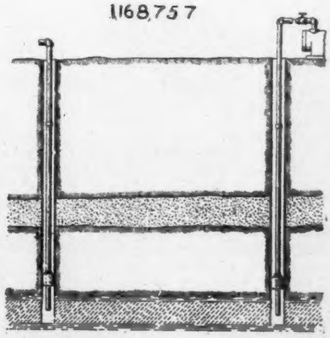
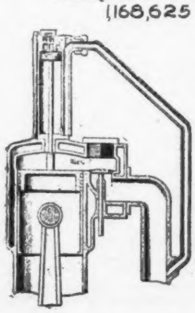

1,168,757


1,168,296

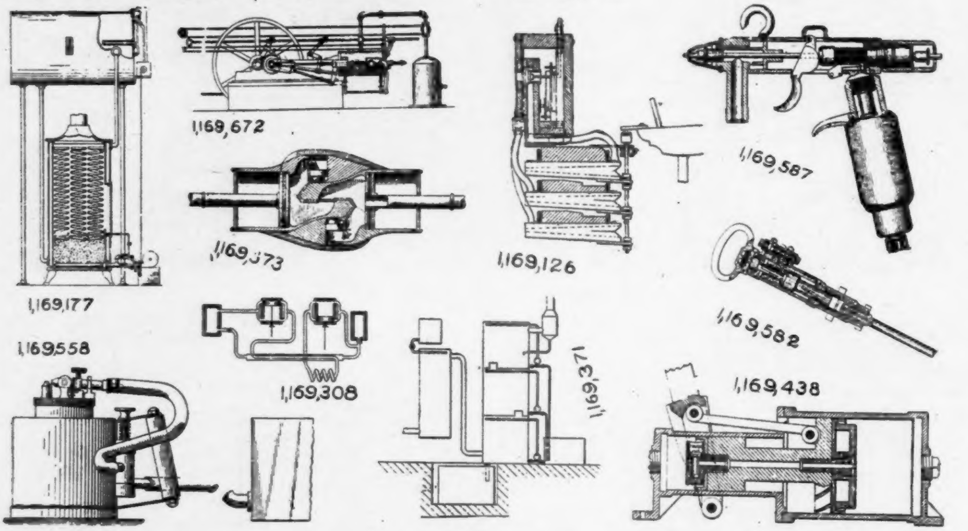
PNEUMATIC PATENTS JANUARY 18.

1,167,740. METHOD OF CONTROLLING THE HUMIDITY OF AIR UNDER PRESSURE. WILLIS H. CARRIER, Buffalo, N. Y.
1,167,910. AUTOMATIC TRAIN-STOPPING DEVICE. HARRY W. MARSTON, Everett, Mass.
1,167,975. PNEUMATIC-TOOL PISTON. WILLIAM BURLINGHAM, Newport News, Va.
1,167,980. INDICATOR FOR PNEUMATIC TIRES. SAMUEL F. COLE, Purcellville, Va.
1,168,001. PNEUMATIC ACTION FOR PIANO-PLAYERS. JOHN HILLSTROM and AMIL HAWKINSON, Chicago, Ill.
1,168,016. MILKING-MACHINE. JAMES F. LEMON and SAMUEL A. MACDONALD, Syracuse, N. Y.
1,168,040. APPARATUS FOR RAISING SUNKEN VESSELS. OLAF M. WICK, Jamestown, N. D.
1,168,105. BLOWER FOR SIGNALING DEVICES. NELSON NYBERG, Miami, Ariz.
1,168,175. VACUUM STREET - CLEANER JAMES E. DEARDORFF, Wichita, Kans.

1. The method of determining the location and probable direction of extent of gas or oil bearing strata which consists in sinking three or more wells to such strata at relatively remote points, creating an artificial pressure at one well which shall be observable at the other wells when the wells communicate with a common stratum, and recording the pressures at all of the wells, whereby the general direction of flow of the fluid in the stratum is indicated.
1,168,758. VACUUM EVAPORATING APPARATUS. GEORGE STADE, Schloss Hubertusberg, Germany.
1,168,924. PNEUMATIC PLAYER MECHANISM. FRANK C. WHITE, Meriden, Conn.
1,169,050. AUTOMATIC AIR - CUSHION. GEORGE W. MACKINNON, Boston, Mass.

JANUARY 25.

1,169,126. PNEUMATIC ACTION FOR INTERIOR PIANO-PLAYERS. MELVILLE CLARK, Chicago, Ill.



PNEUMATIC PATENTS JANUARY 25.

1,168,225. CARPET-CLEANER. FRANK J. QUIST, Worcester, Mass.
1,168,251. AIR-COMPRESSOR MOTOR. DAVID E. CROUSE and CHARLES G. EIDSON, Annapolis, and THOMAS DAVIS, Baltimore, Md.

JANUARY 18.

1,168,296. POWER TIRE-PUMP. FREDERICK G. FOLBERTH, Cleveland, Ohio.
1,168,426. AUTOMATIC AIR-HOSE COUPLING. JOHN ROY, Los Angeles, Cal.
1,168,456. COUPLING FOR AIR CONDUITS. MELVILLE ARNOLD, Lima, Ohio.
1,168,488. TRIP-VALVE FOR AIR-BRAKES. EDWARD H. DEWSON, New York, N. Y.
1,168,493. AIR-BLAST COTTON-GIN. CARROLLVERNON B. GINN, Brenham, Tex.
1,168,506. PNEUMATIC ELECTRIC FIRE-ALARM. CHRISTIAN JOHN JENNE, San Francisco, Cal.
1,168,625. COMPRESSOR. LEE H. GEISENDORFF, Indianapolis, Ind.
1,168,677. AUTOMATIC TRAIN-PIPE COUPLING. GEORGE G. ROSS, HARRY E. ROSS, and LEO D. ROSS, Greensburg, Pa.
1,168,691. PNEUMATIC PLAYER MECHANISM. FRANK C. WHITE, Meriden, Conn.
1,168,757. METHOD OF LOCATING NATURAL GAS. FREDERICK SQUIRES, McConnelsville, Ohio.

1,169,131-2. ACTION FOR PIANO-PLAYERS. CHARLES L. DAVIS, Detriot, Mich.
1,169,177. CONFINED - COMBUSTION GAS-BURNING APPARATUS. LEE B. METTLER, Kansas City, Mo.
1,169,277. VALVE FOR PNEUMATIC TIRES. JOSEPH N. NEWSOM, St. Louis, Mo.
1,169,308. HOT-AIR ENGINE WITH CLOSED CIRCUIT. TRAJAN VUIA, Neuilly-on-Seine, France.
1,169,371. METHOD OF DRYING AIR FOR METALLURGICAL USES. WILHELM WENSE, Griesheim-on-the-Main, Germany.
1,169,373. TRAIN-PIPE COUPLING. WALTER C. WHITE, Los Angeles, Cal.
1,169,438. AIR-PUMP. CLAYTON S. STEVENS, New Britain, Conn.
1,169,527. VACUUM-CLEANER. CHARLES A. BOYER, Warsaw, Ind.
1,169,558. SPRAYING DEVICE FOR LIQUID PAINT AND THE LIKE. GEORGE MORE, Richmond Hill, and EDWARD W. SPIES, New York, N. Y.
1,169,582. DRILLING OR BORING TOOL. WILLIAM MAINE TREGLOWN and WILLIAM NOBLE, London, England.
1,169,587. AIR - BRUSH. OLAUS C. WOLD, Chicago, Ill.
1,169,672. COMBINED GAS AND AIR ENGINE. VICTOR H. PALM, Butler, Pa.